Use of the AIRS data in the Research of UTLS chemistry and dynamics

Laura Pan, NCAR

With contributions from :

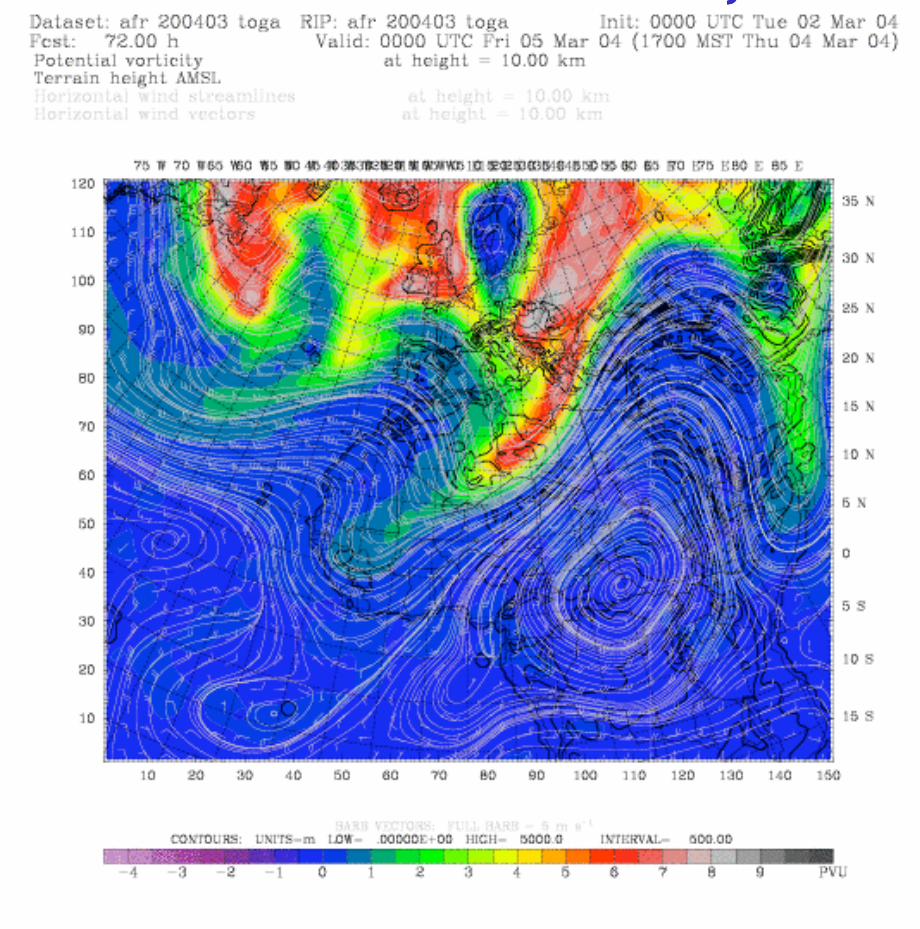
- Bill Randel, Andrew Gettelman (NCAR)
- Jennifer Wei, Chris Barnet (NOAA)
- Bill Irion (JPL)

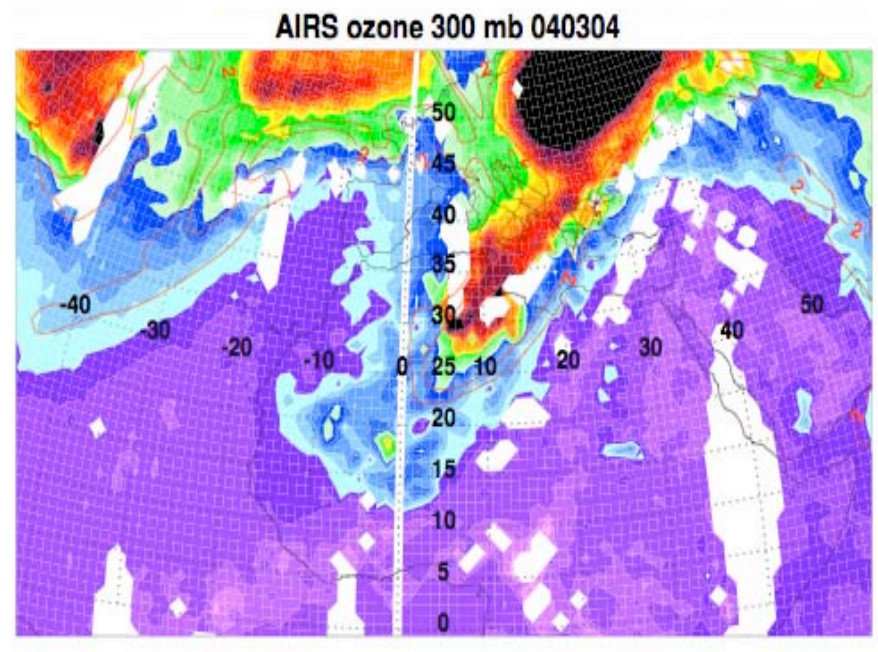
Plan for the talk

- Validation studies for V4 and V5
- V6 Ozone Retrieval ?

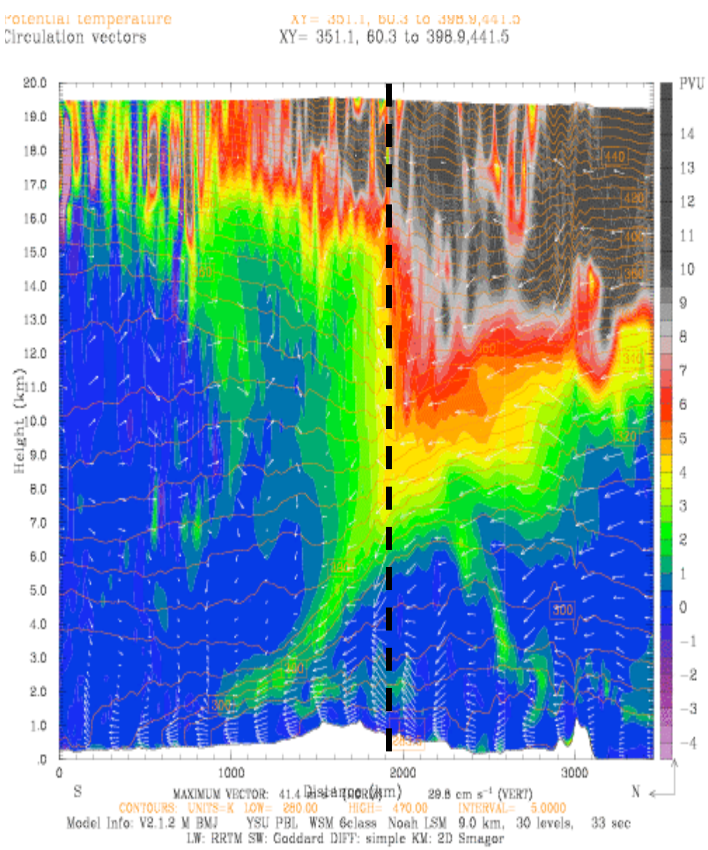
- Global perspective of ExTL based on tracer correlation of AIRS ozone and water vapor

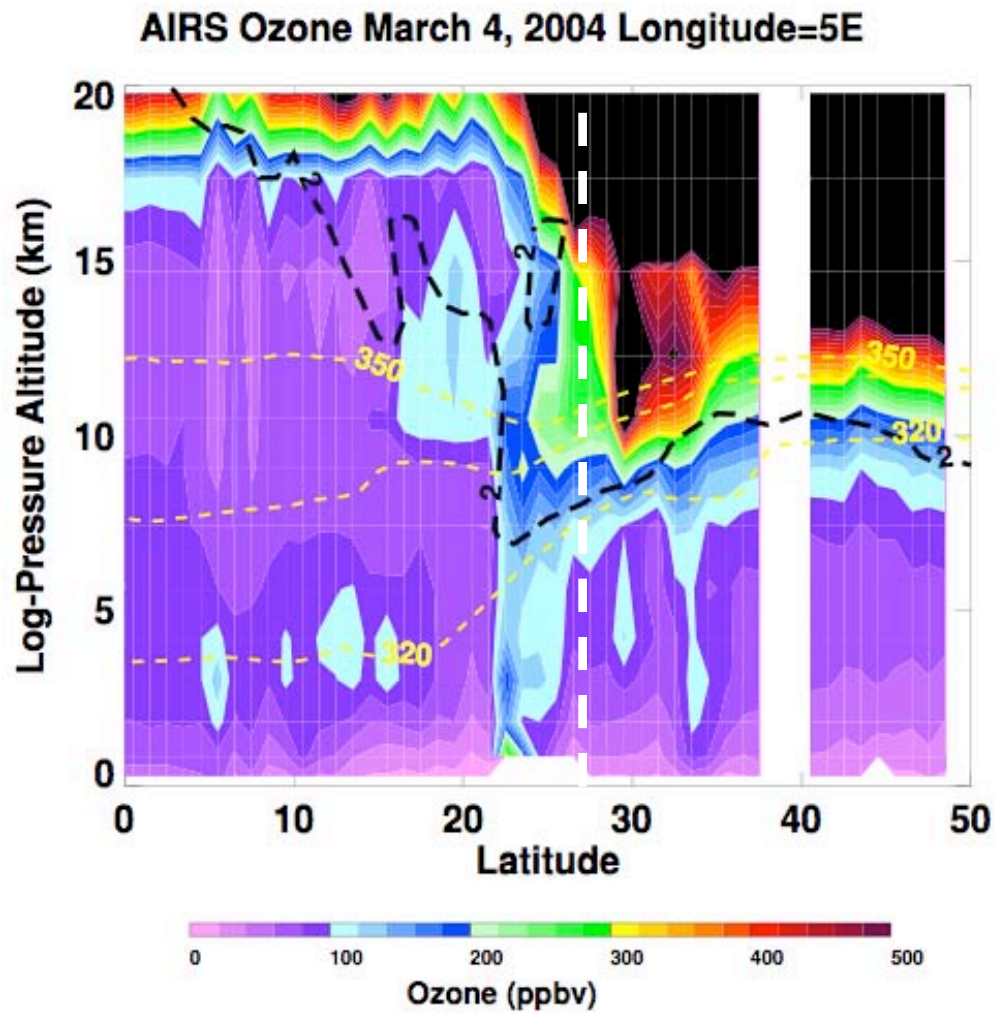
PV from NCAR WRF/ARW model and AIRS Ozone, March 4th, 2004





PV from NCAR WRF model and AIRS Ozone cross section





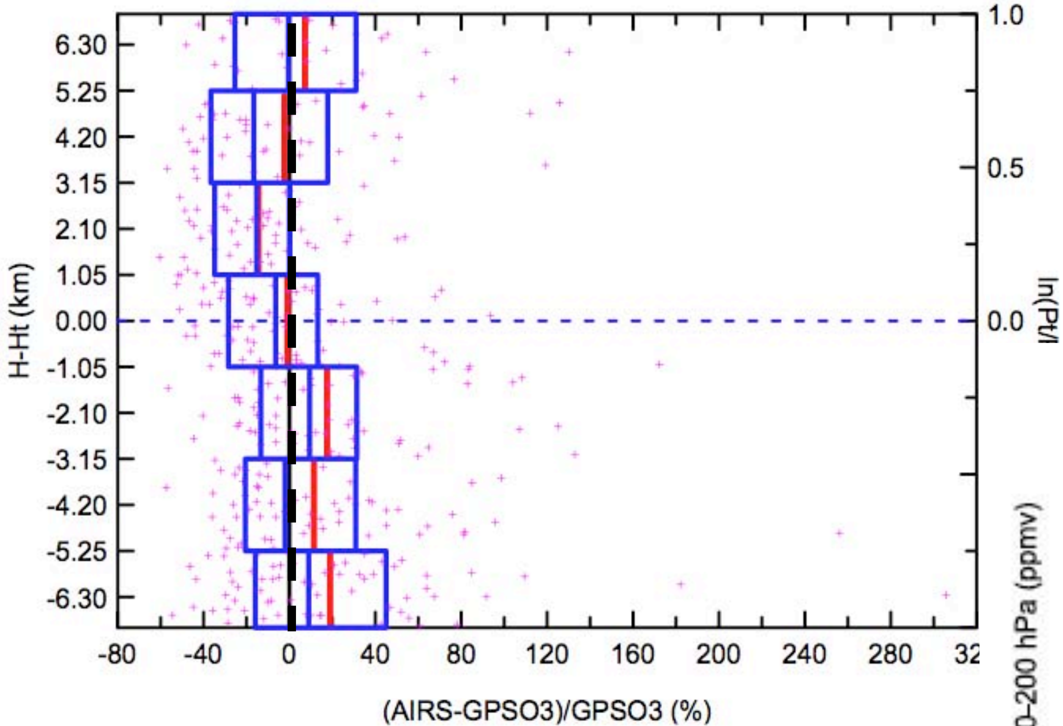
2007 Publications involving AIRS ozone

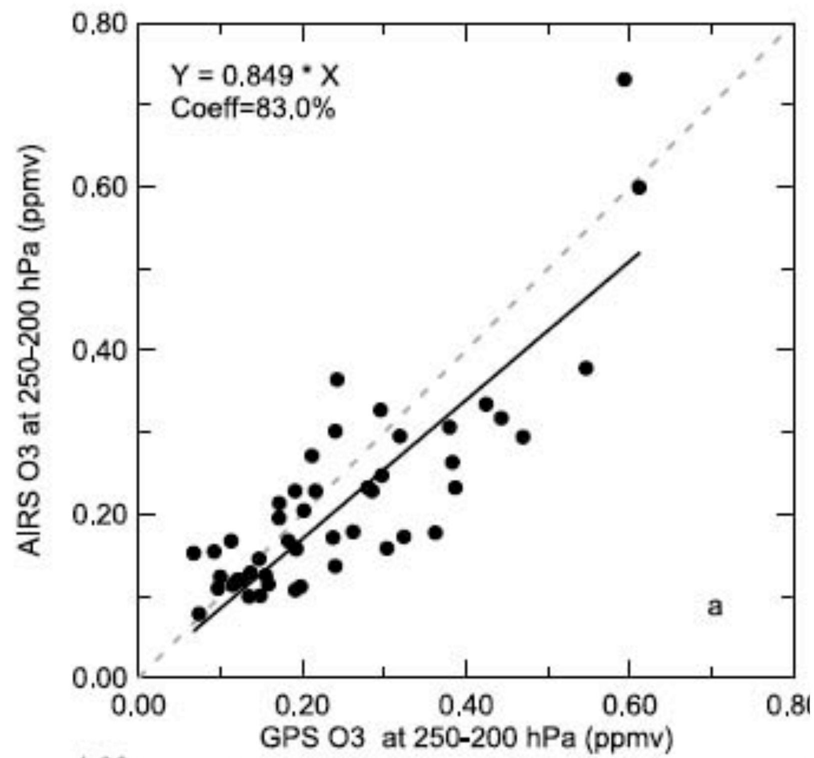
- Bian J., A. Gettelman, H. Chen, L. L. Pan (2007), Validation of satellite ozone profile retrievals using Beijing ozonesonde data, J. Geophys. Res., 112, D06305, doi:10.1029/2006JD007502.

- Monahan K. P., L. L. Pan, A. J. McDonald, G. E. Bodeker, J. Wei, S. E. George, C. D. Barnet, E. Maddy (2007), Validation of AIRS v4 ozone profiles in the UTLS using ozonesondes from Lauder, NZ and Boulder, USA, J. Geophys. Res., 112, D17304, doi:10.1029/2006JD008181.

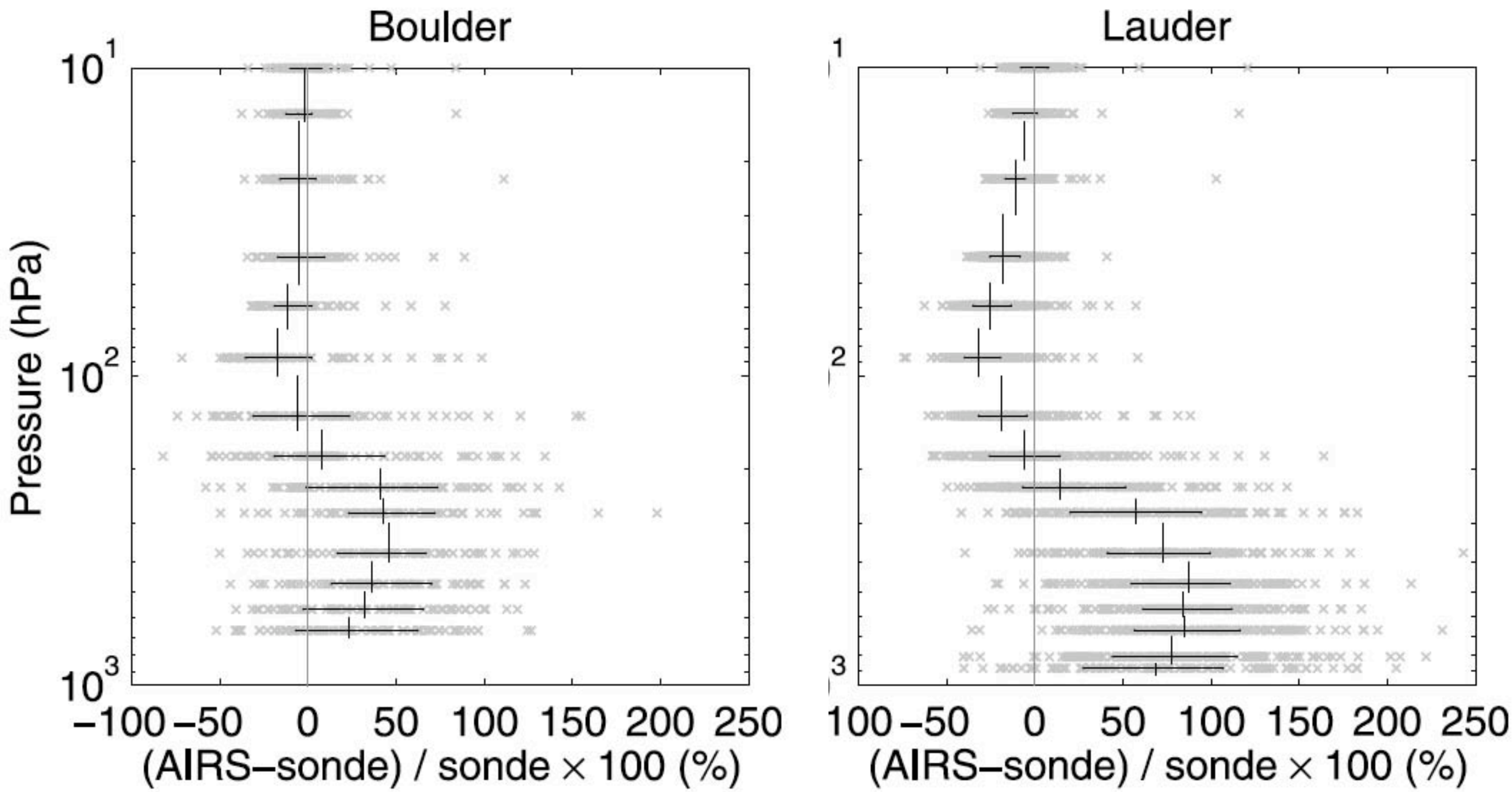
- Pan L. L., et al. (2007), Chemical behavior of the tropopause observed during the Stratosphere-Troposphere Analyses of Regional Transport experiment, J. Geophys. Res., 112, D18110, doi:10.1029/2007JD008645.

Bian et al. 2007

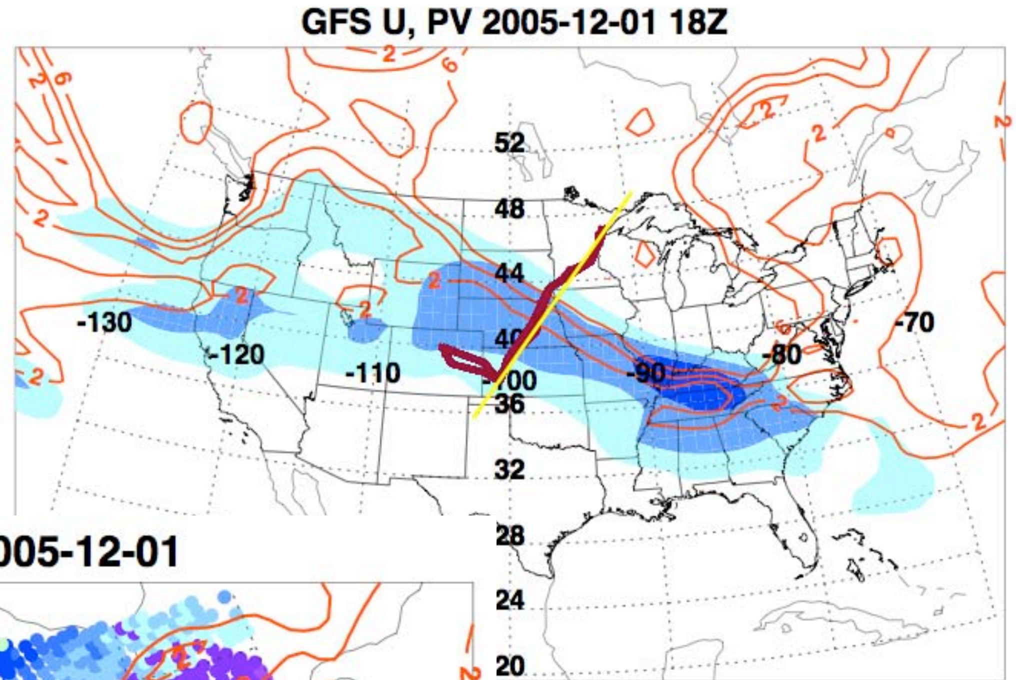


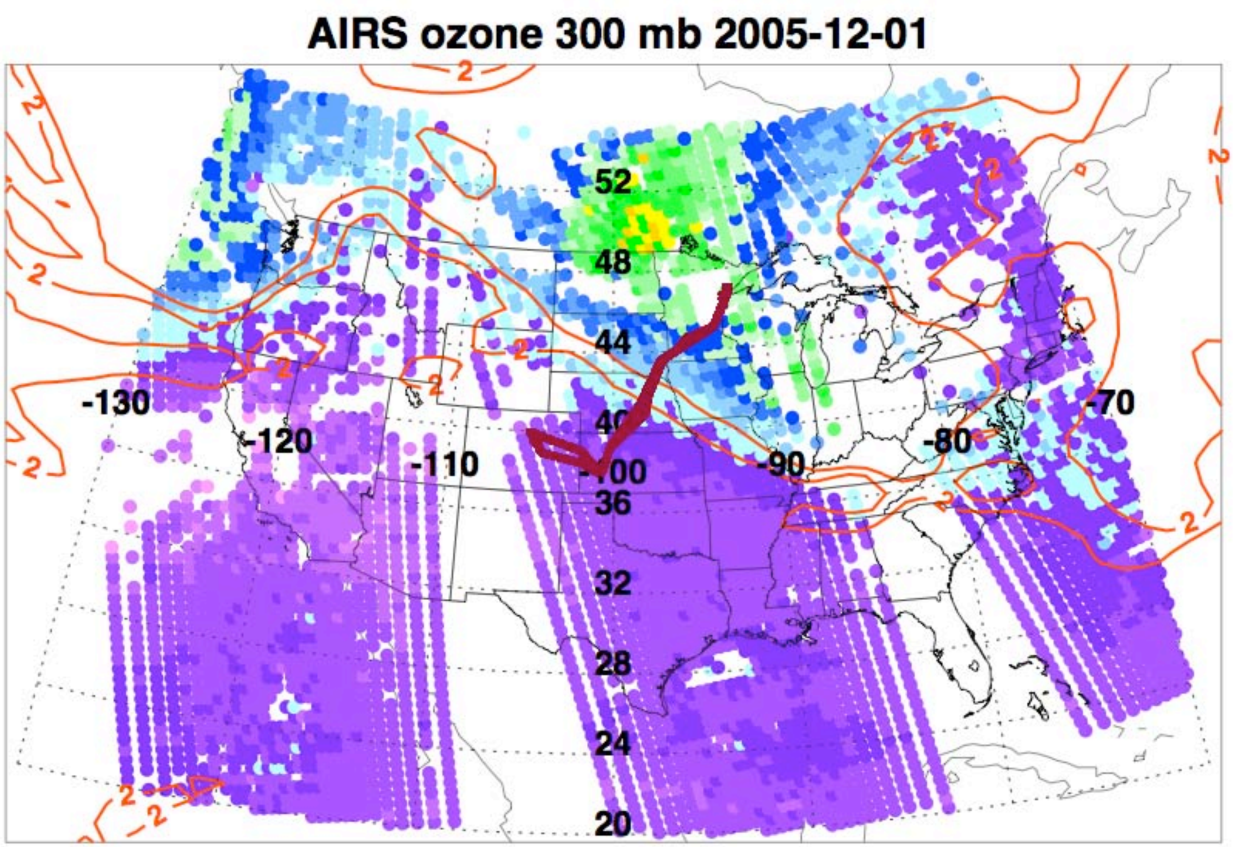


Monahan et al., 2007



START Flight 1, 2005-12-01

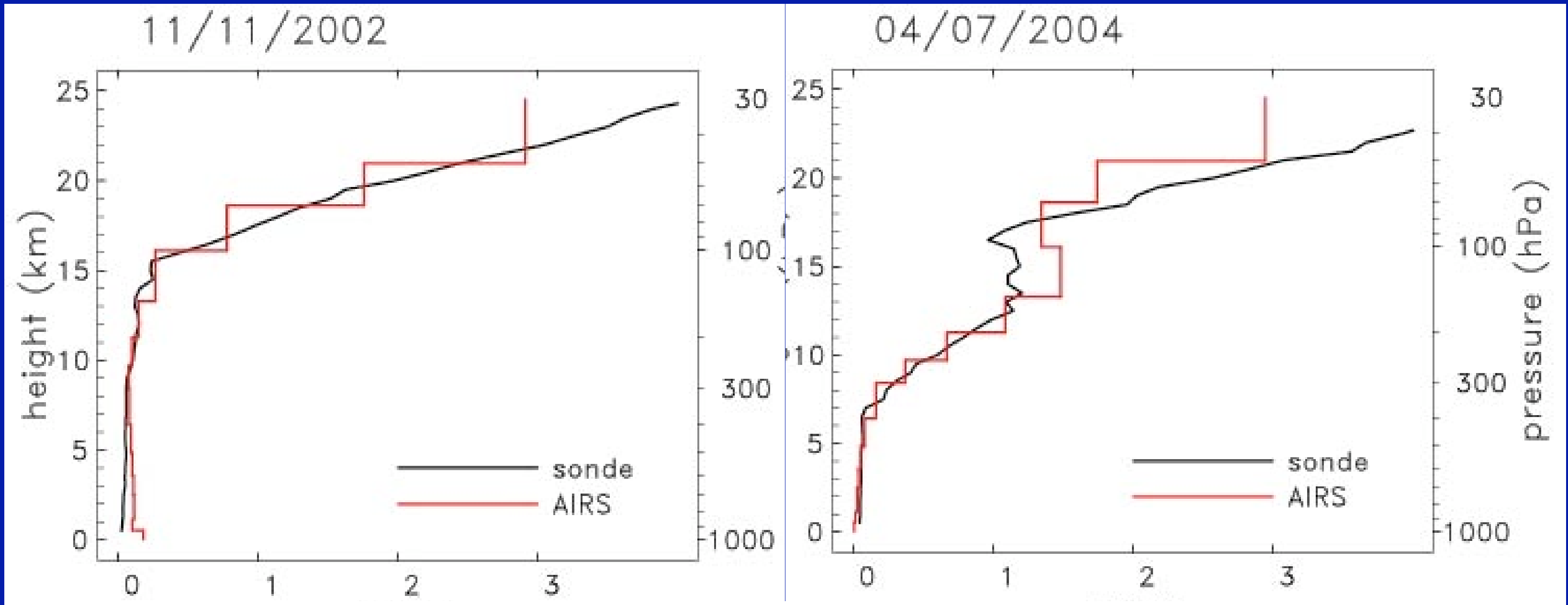




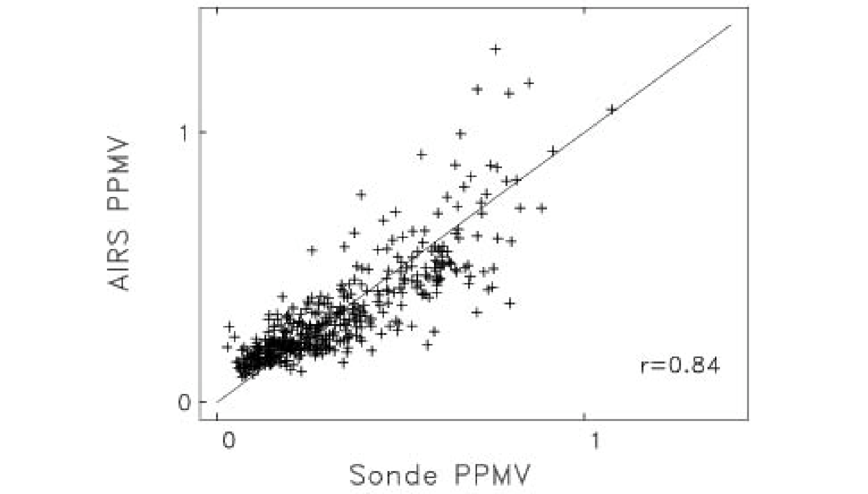
Pan et al., 2007

Unpublished validation studies

There are examples of excellence agreement between AIRS ozone profiles and ozonesondes.



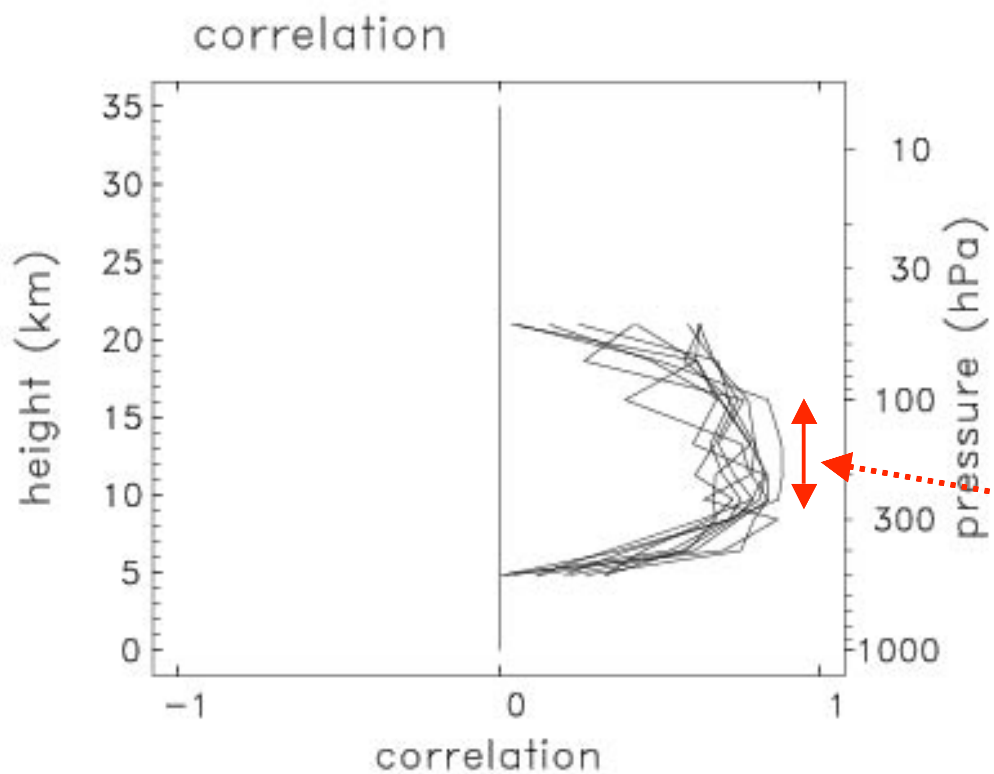
(200hPa ozone, using 442 soundings during 2003-2005)



Payerne, Switzerland (47N)

AIRS – ozonesonde correlations at 9 stations:

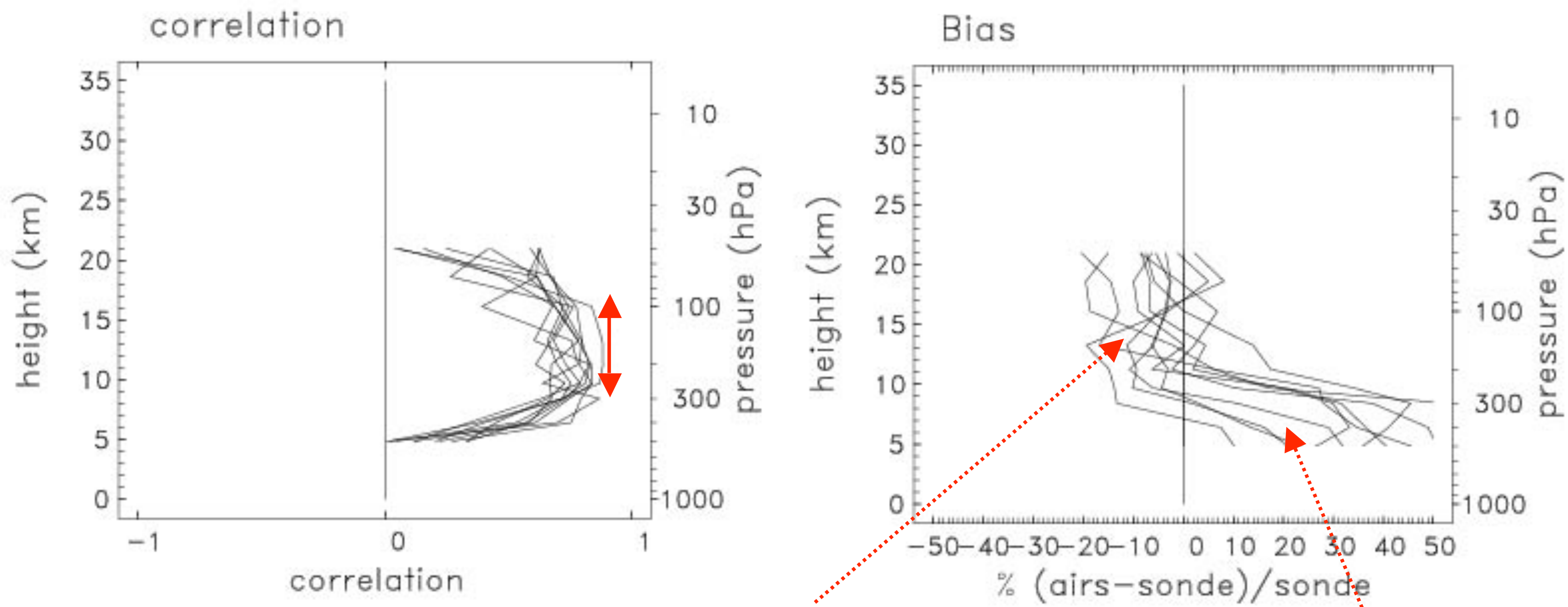
Station	#
Boulder	122
Payerne	442
Sapporo	128
Tateno	149
Edmonton	104
Goosebay	84
Churchill	75
Resolute	46
Lauder	135



high correlations
at each station
over ~100 – 300 hPa

Randel et al., Unpublished

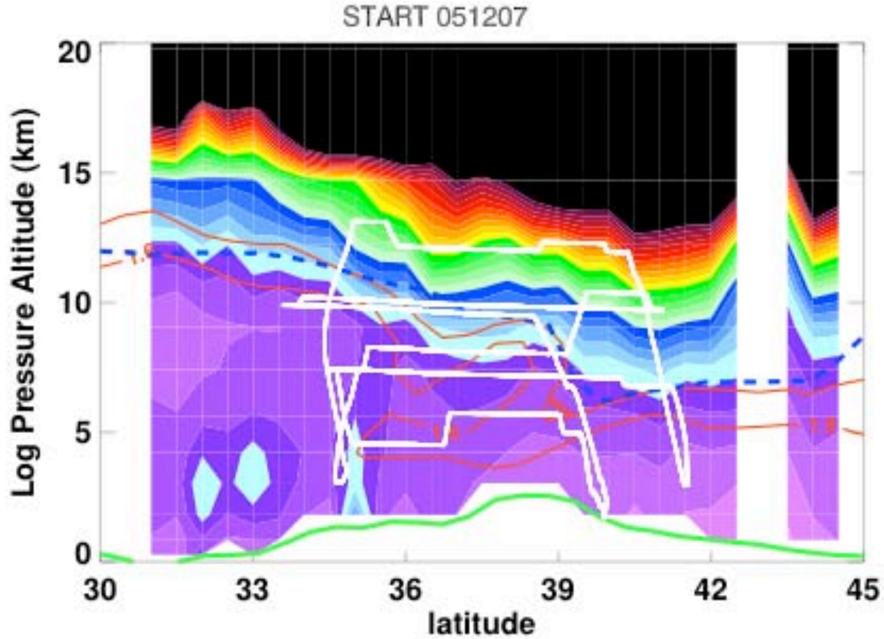
AIRS – ozonesonde correlations and biases
(9 stations, 2003-2005)

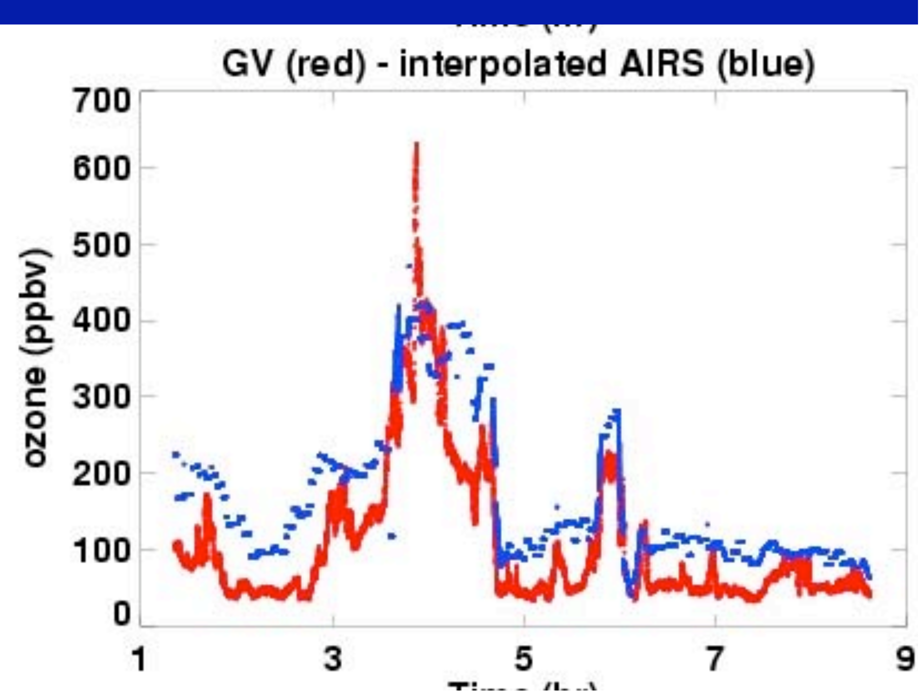


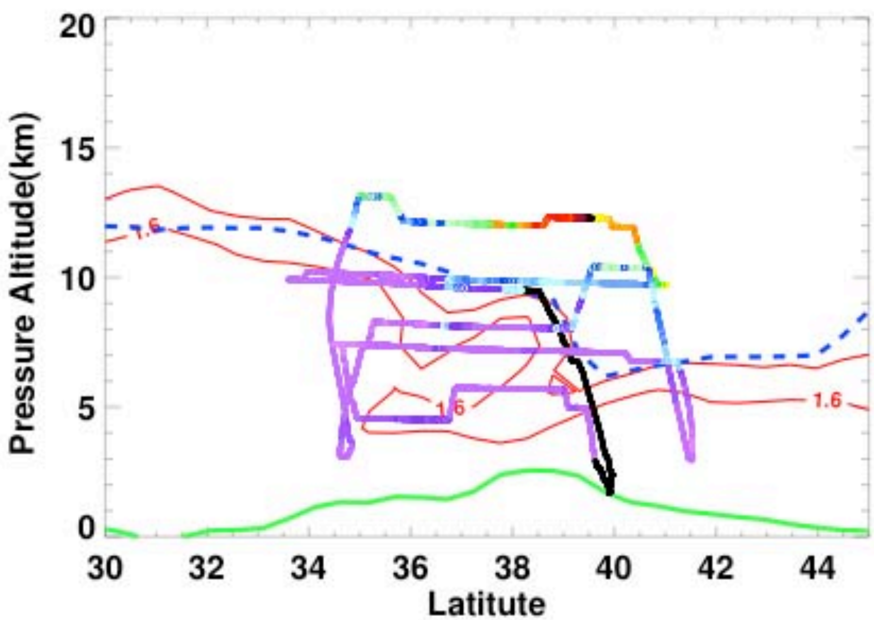
small AIRS
low bias

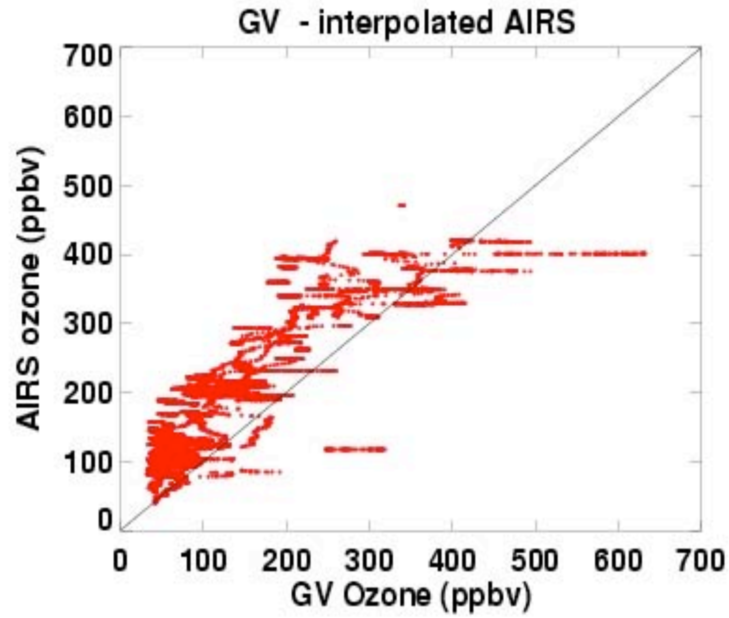
significant AIRS
high bias below
~ 250 hPa

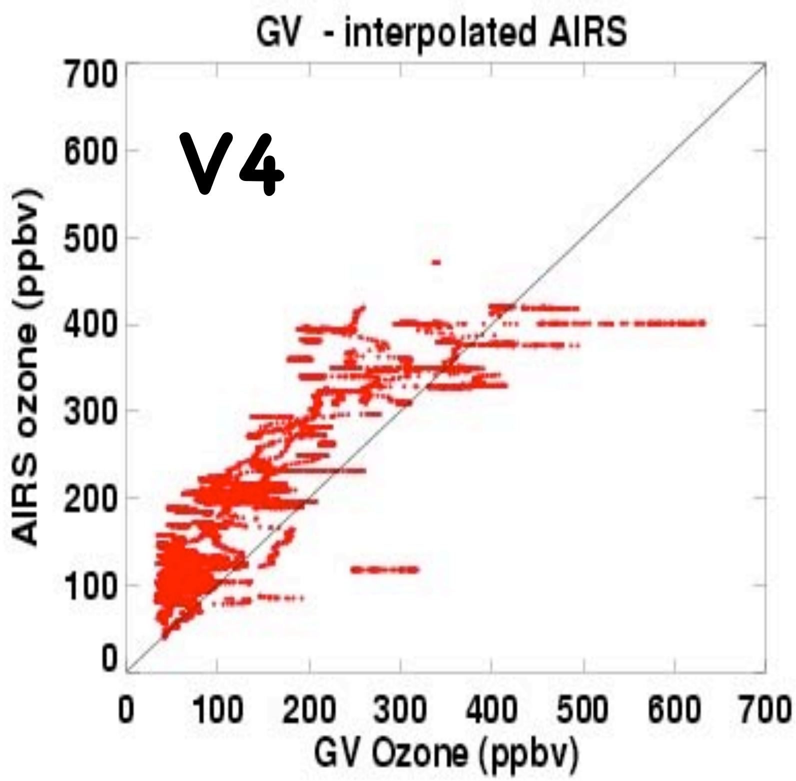
START, Dec 7, 2005

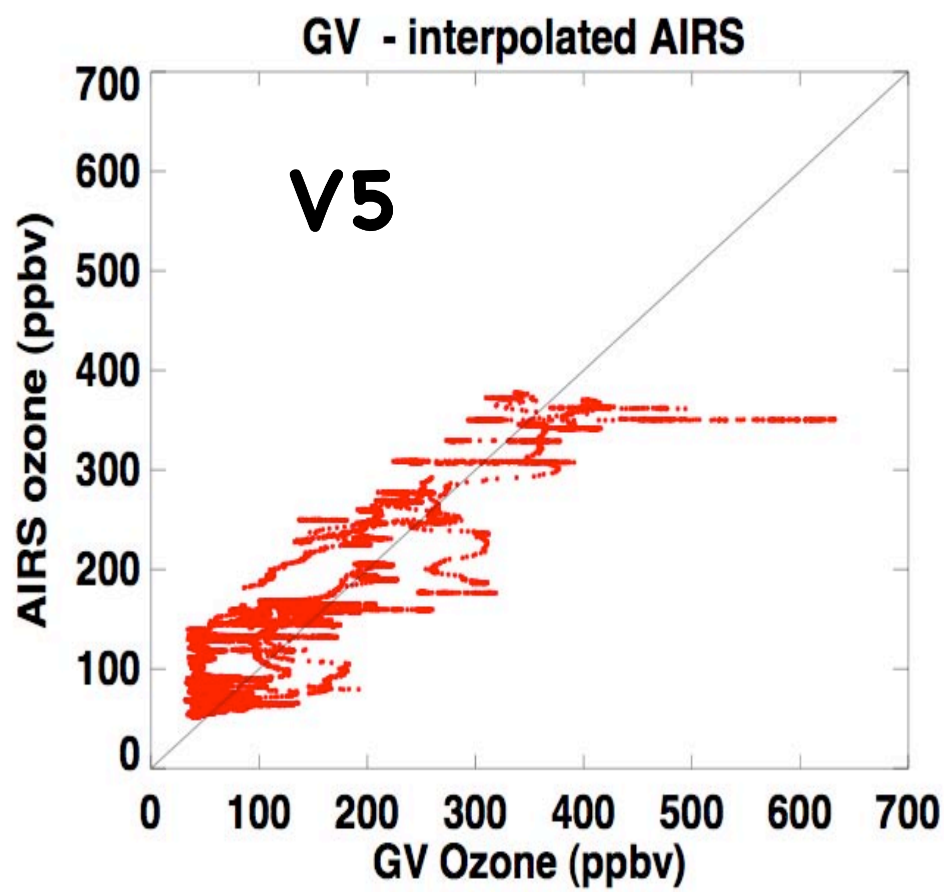




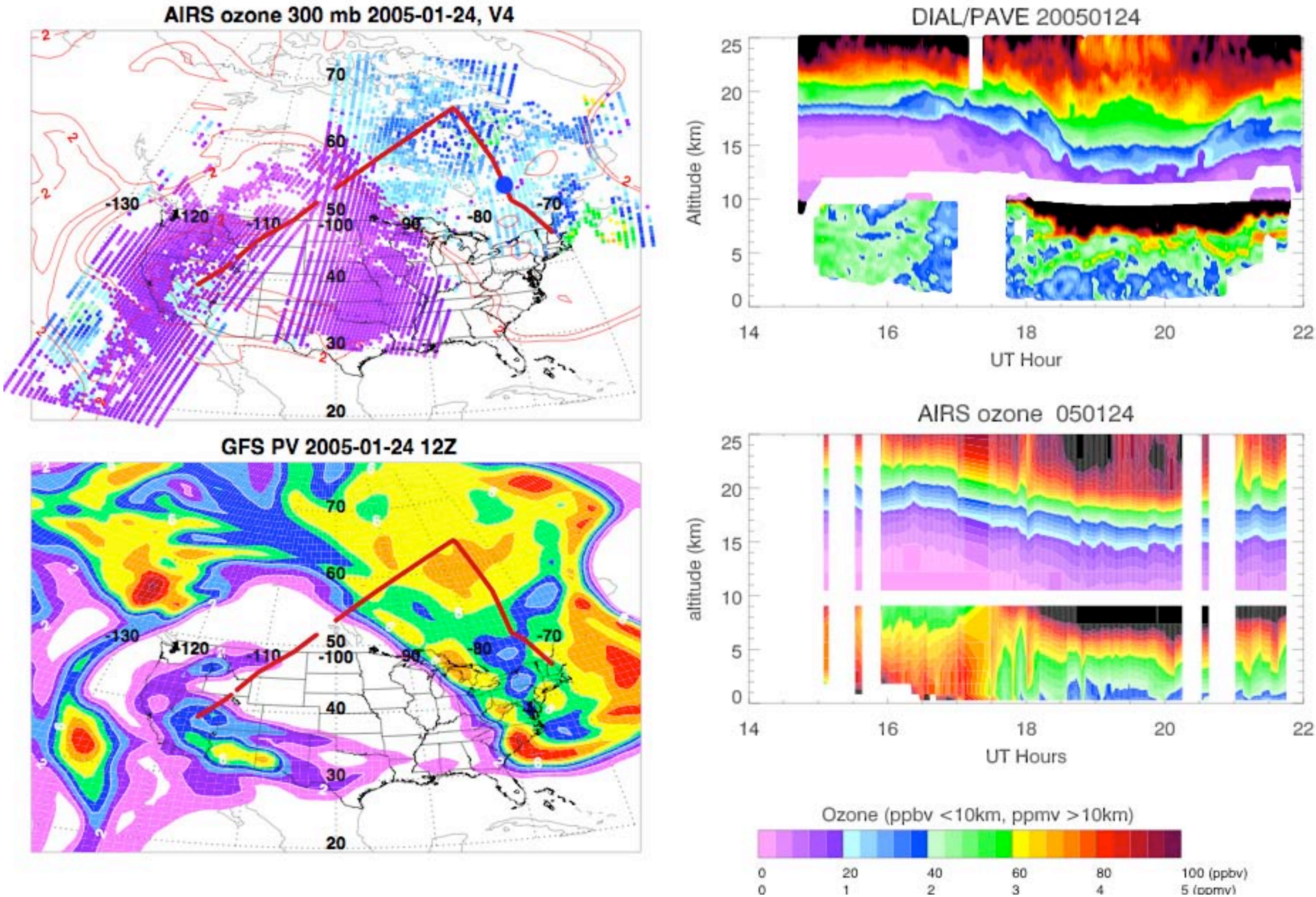


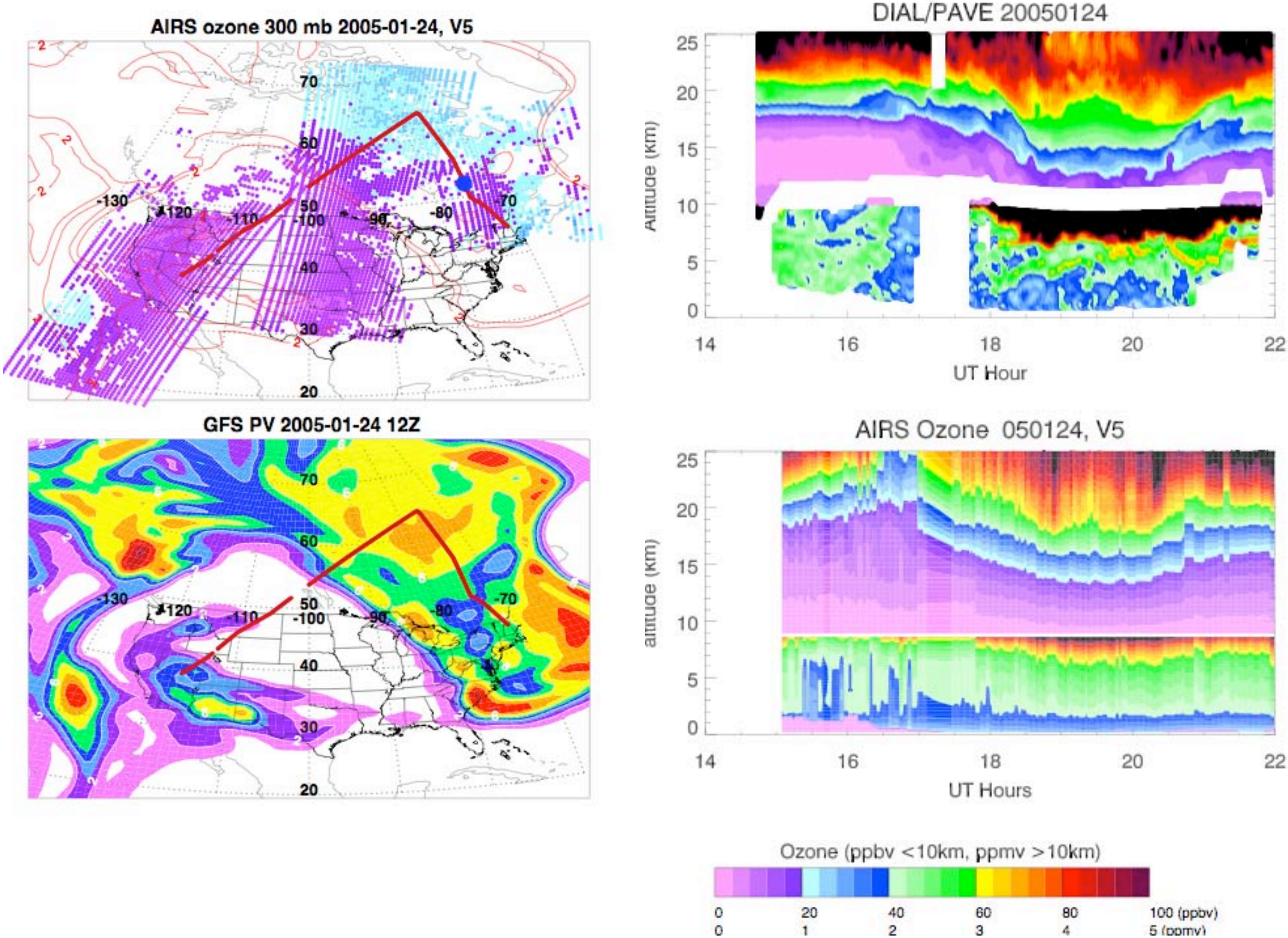



GV - interpolated AIRS
V4
AIRS ozone (ppbv)
GV Ozone (ppbv)
0
100
200
300
400
500
600
700


GV - interpolated AIRS
V5
AIRS ozone (ppbv)
GV Ozone (ppbv)
0
100
200
300
400
500
600
700

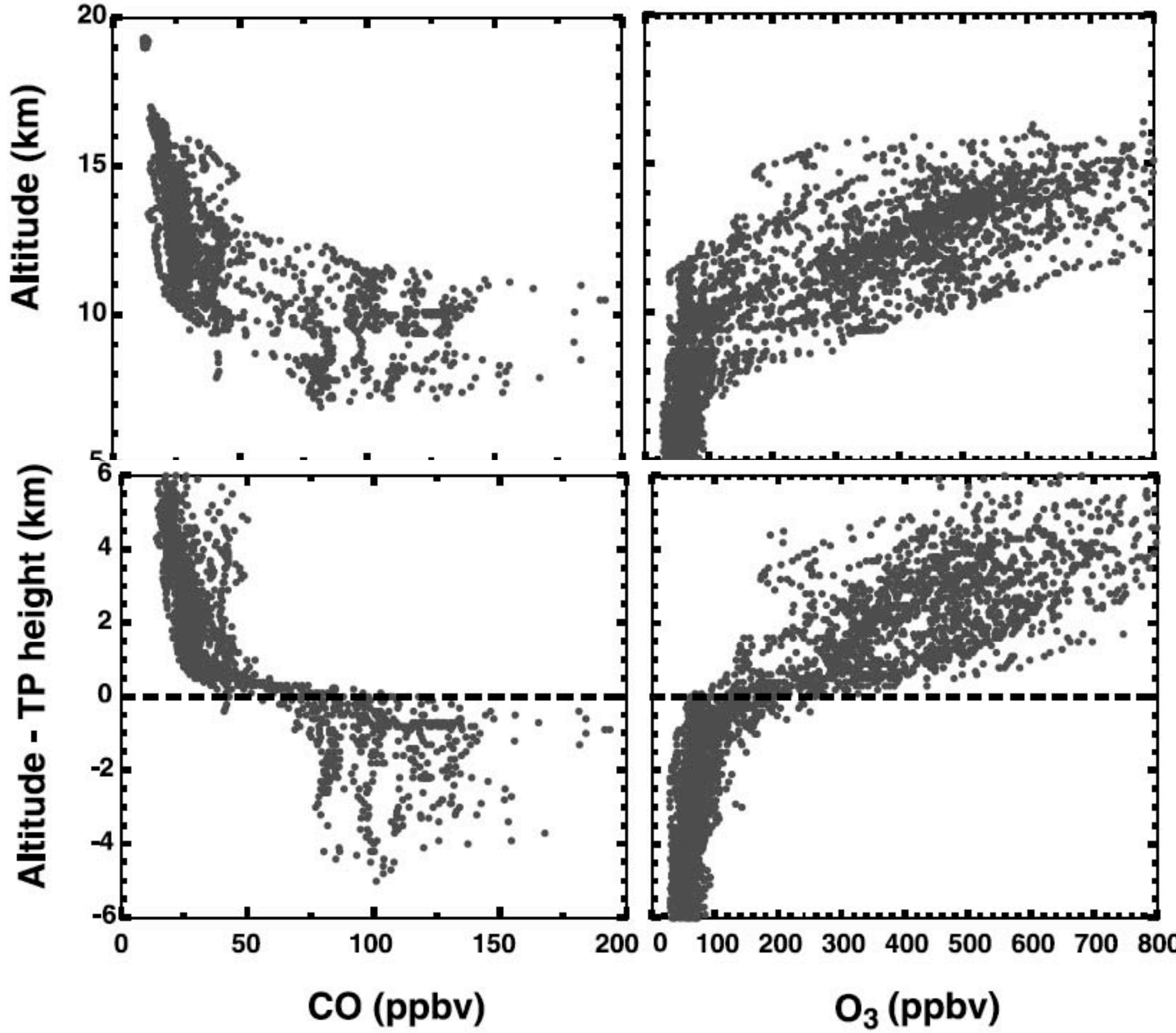
Case 3: NASA Langley DIAL, DC-8 PAVE Jan 2005




AIRS ozone 300 mb 2005-01-24, V5
GFS PV 2005-01-24 12Z
DIAL/PAVE 20050124
Altitude (km)
UT Hour
AIRS Ozone 050124, V5
altitude (km)
UT Hours
Ozone (ppbv <10km, ppmv >10km)
0 20 40 60 80 100 (ppbv)
0 1 2 3 4 5 (ppmv)

Ozone A priori for Version 6 retrieval

Consideration of a tropopause referenced climatology

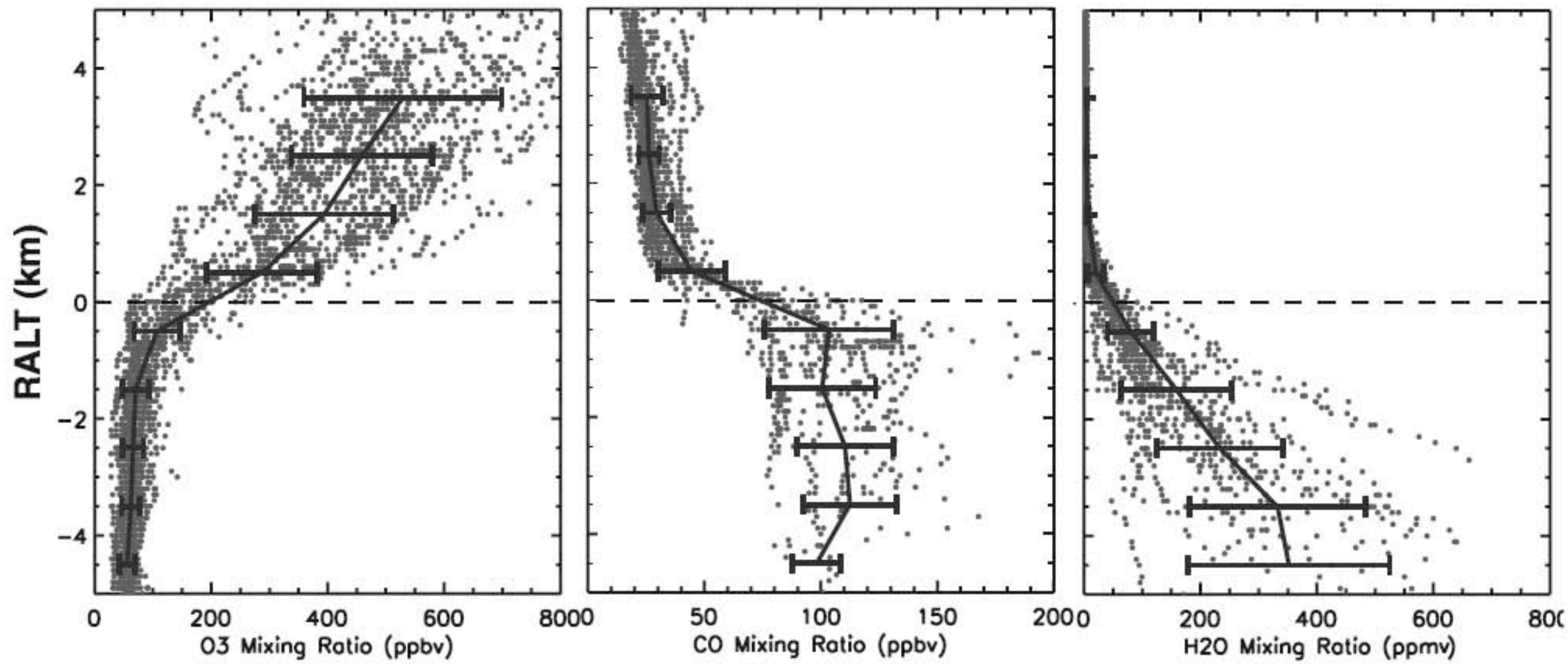


Altitude

Tropopause referenced Relative Alt.

Pan et al, 2004

The "Relative Altitude Coordinates" (to locate the chemical transition between St–Tr)



[Pan et al., 2007]

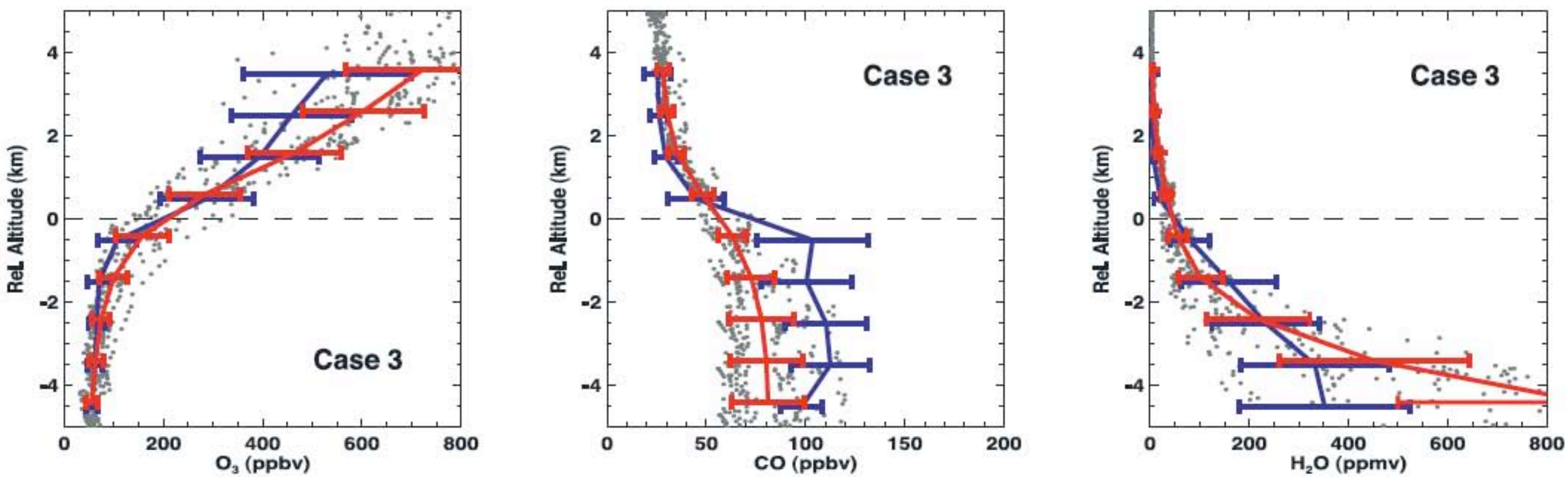
Chemistry-Climate Model Validation Activity for SPARC

(CCMVal)

Scope:

SPARC has established the **Chemistry-Climate Model Validation Activity (CCMVal)** for coupled chemistry-climate models (CCMs). The goal of CCMVal is to improve understanding of Chemistry-Climate Models (CCMs) and their underlying GCMs (General Circulation Models) through process-oriented evaluation, along with discussion and coordinated analysis of science results.

One outcome of this effort is expected to be improvements in how well CCMs represent physical, chemical, and dynamical processes. In addition, this effort will focus on understanding the ability of CCMs to reproduce past trends and variability and providing predictions from ensembles of long model runs. Achieving these goals will involve comparing CCM constituent distributions with (robust) relationships between constituent variables as found in observations. This effort is both a model-model and model-data comparison exercise. Key diagnostics with respect to radiation, dynamics, transport, and stratospheric chemistry and microphysics are defined in the CCMVal Evaluation Table. This approach allows modelers to decide (based on their own priorities and resources) which diagnostics to examine in any particular area. The CCMVal activity helps coordinating and organizing CCM model efforts around the world. In this way, the CCM community can provide the maximum amount of useful scientific information for WMO/UNEP and IPCC assessments.

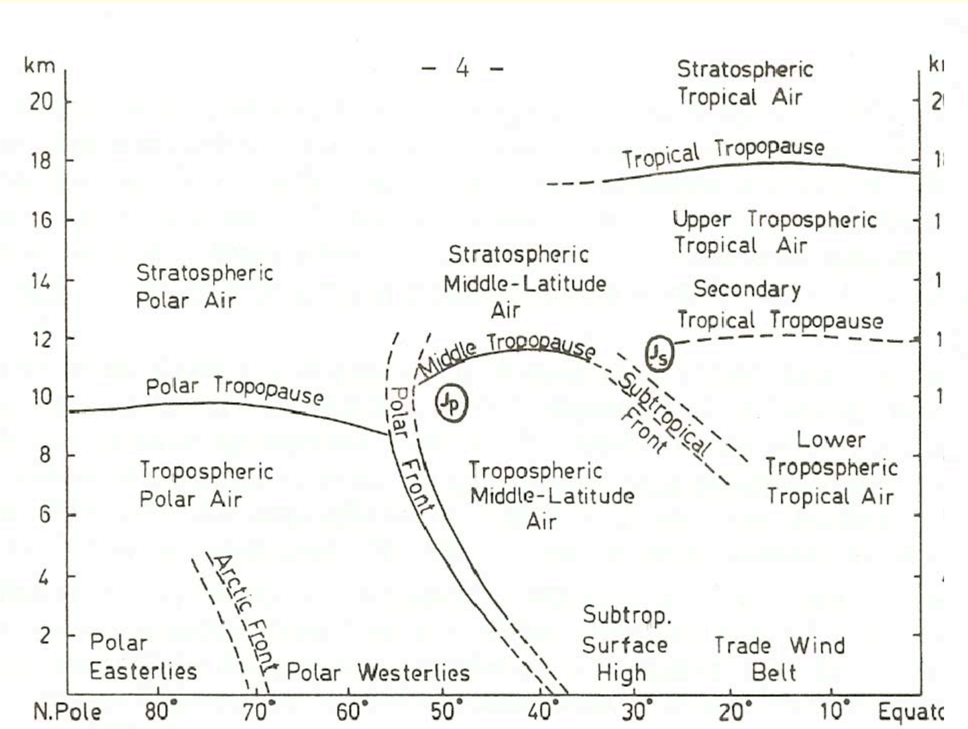


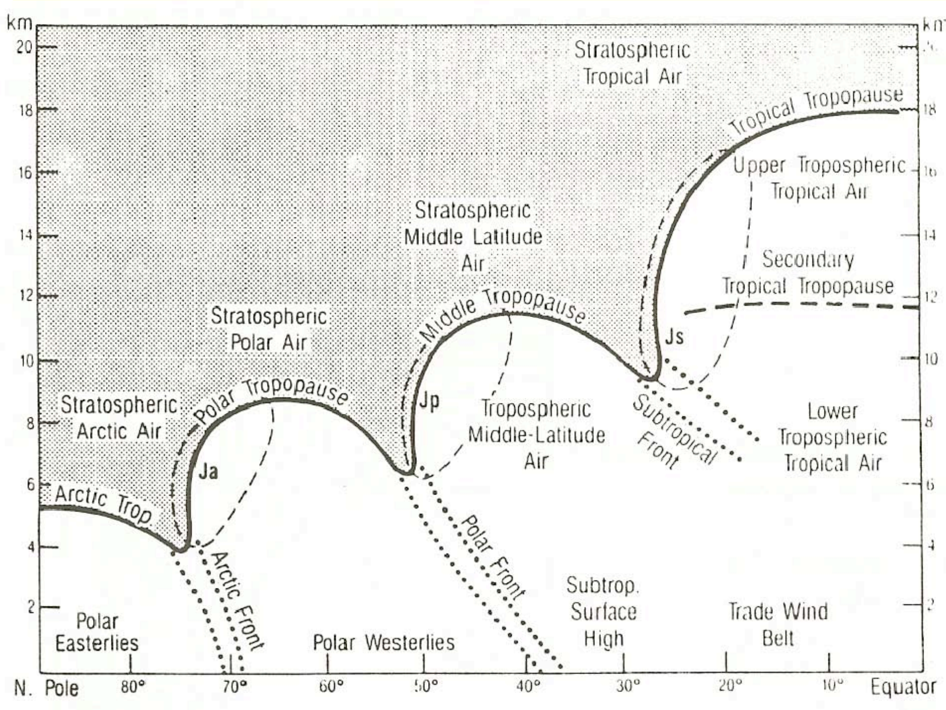
Pan et al., 2007

Global perspective of ExTL based on AIRS ozone and water vapor

Historical Models of the Tropopause

"The Thermal Tropopause" **"The Dynamical Tropopause"**





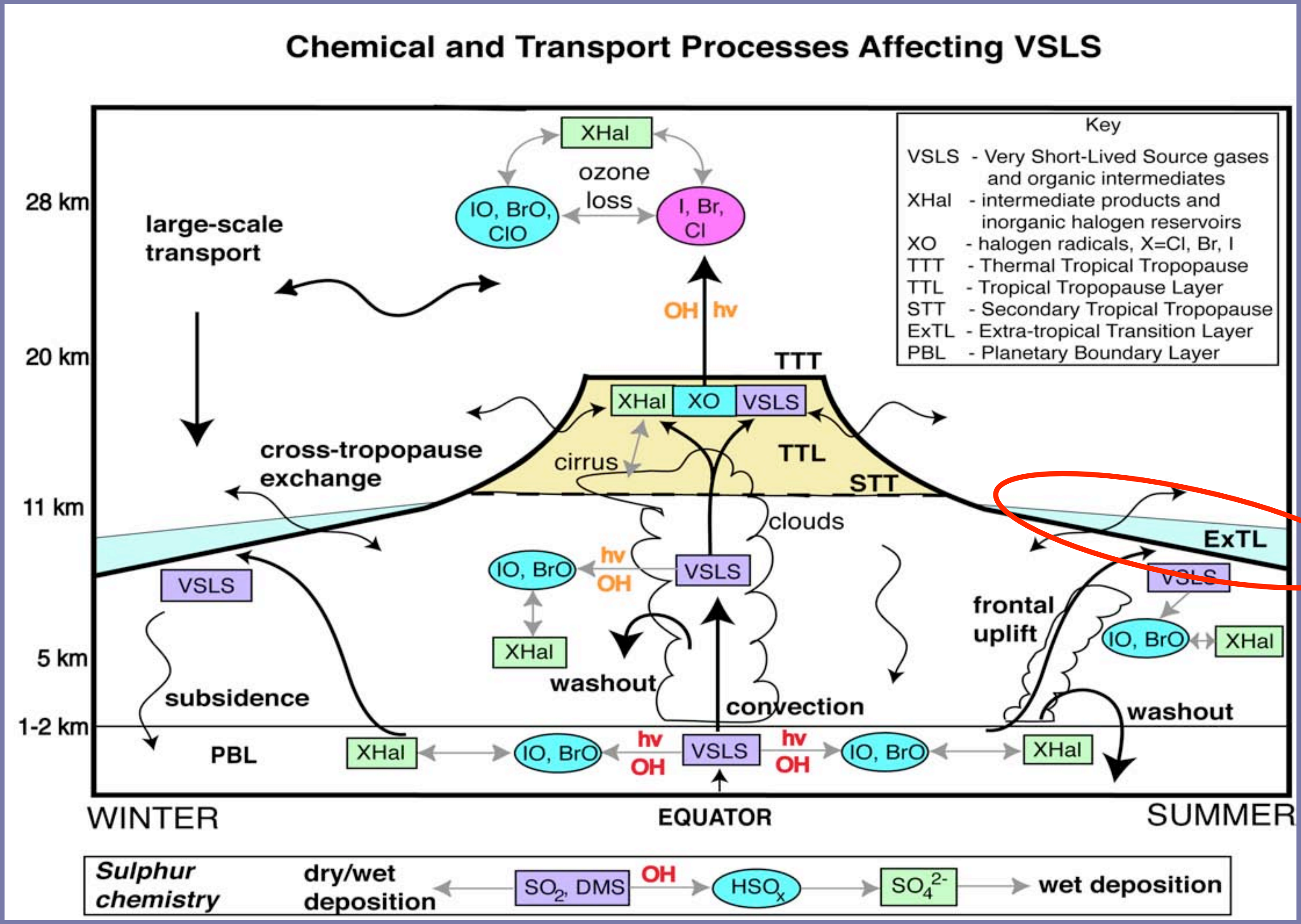
Palmen & Newton, 1969

(WMO, 1957)

Shapiro & Keyser, 1990

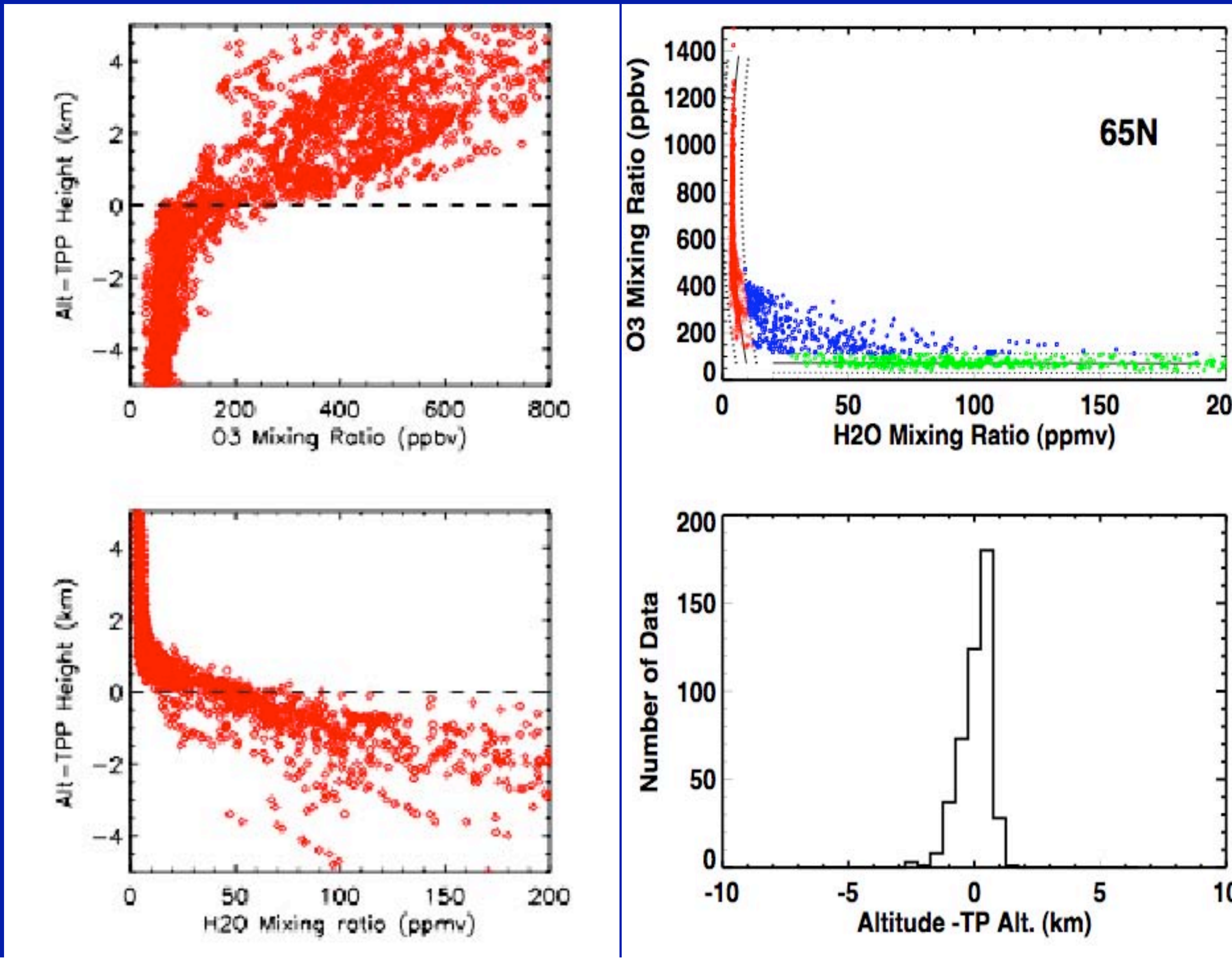
(Reed, 1955, Shapiro, 1980; Danielsen etal., 1987; WMO, 1986; Holton et al., 1995;…)

Contemporary Concept of Extratropical Transition Layer

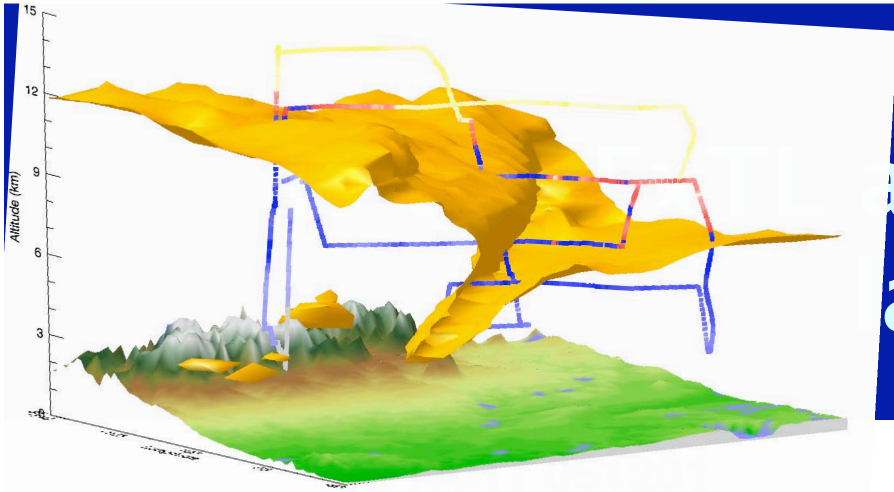


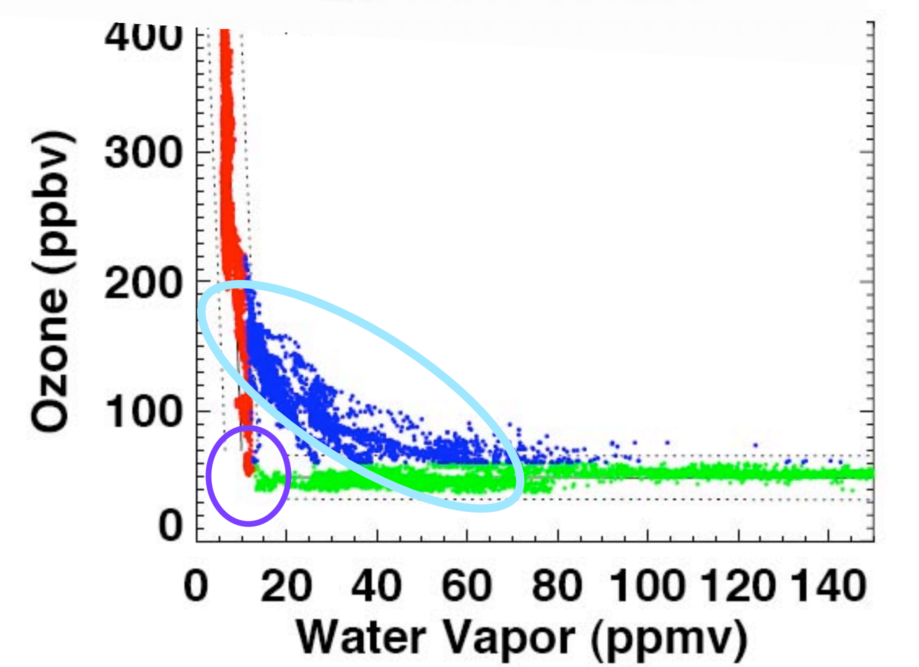
Adapted from Chapter 2 WMO (2002), Law, Cox & Haynes

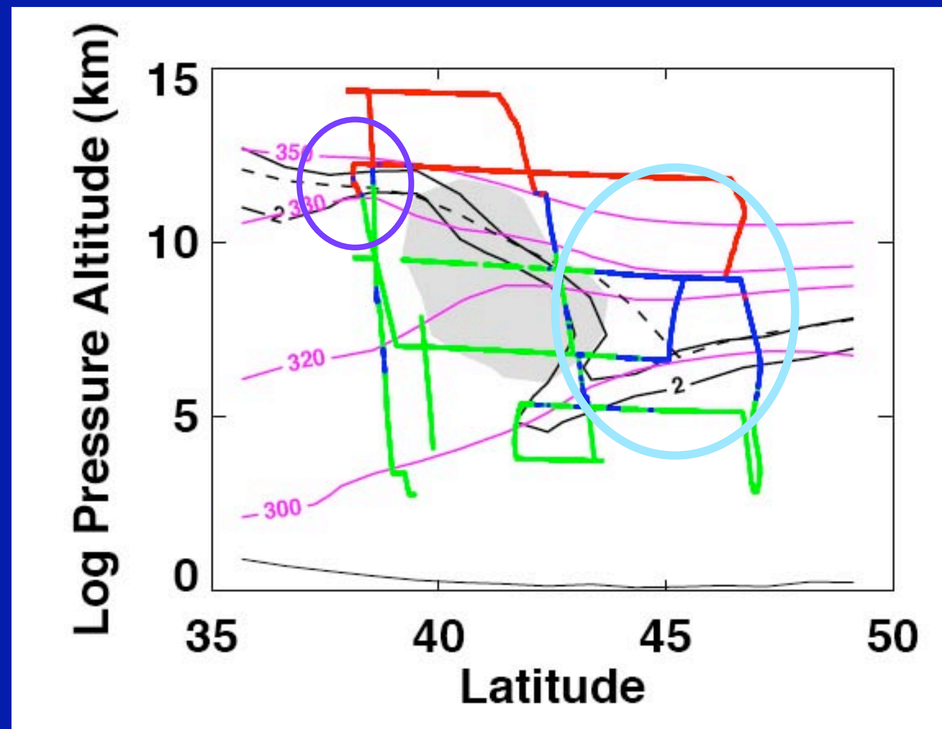
ER-2 data O_3-H_2O (POLARIS)



a uniform mixing
ayer?



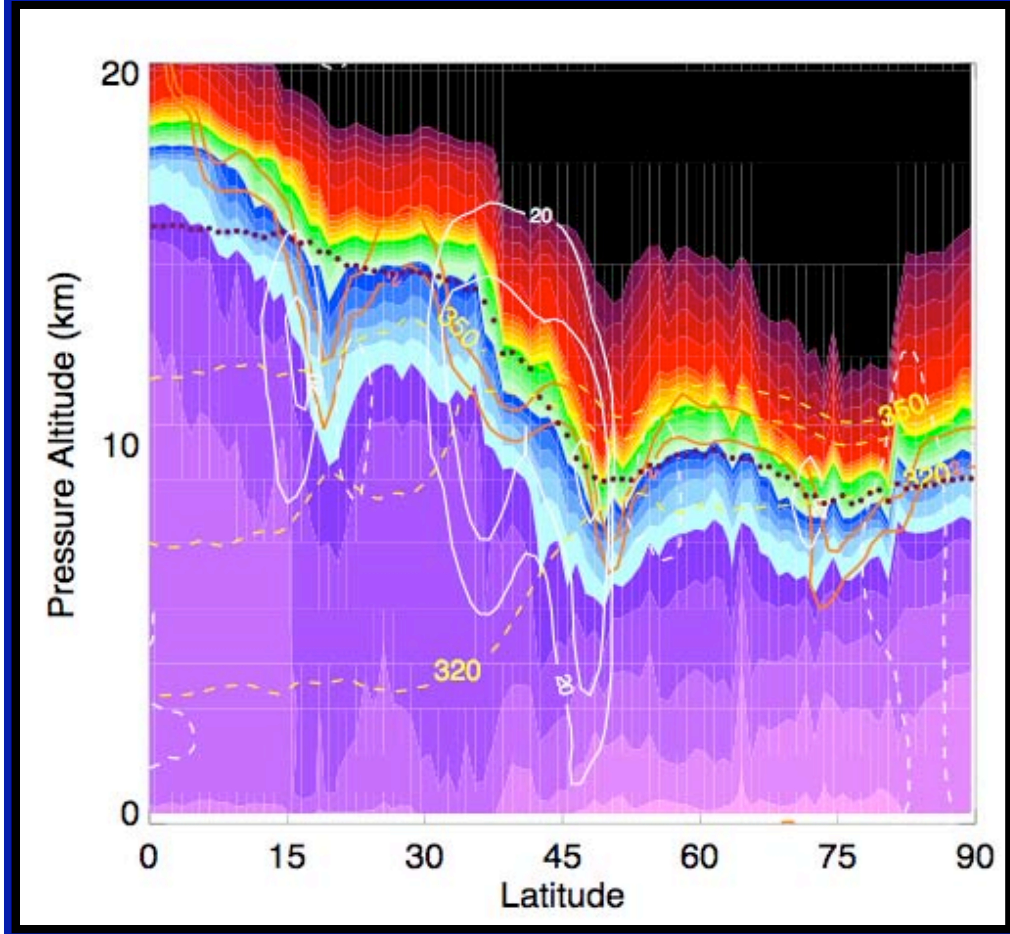




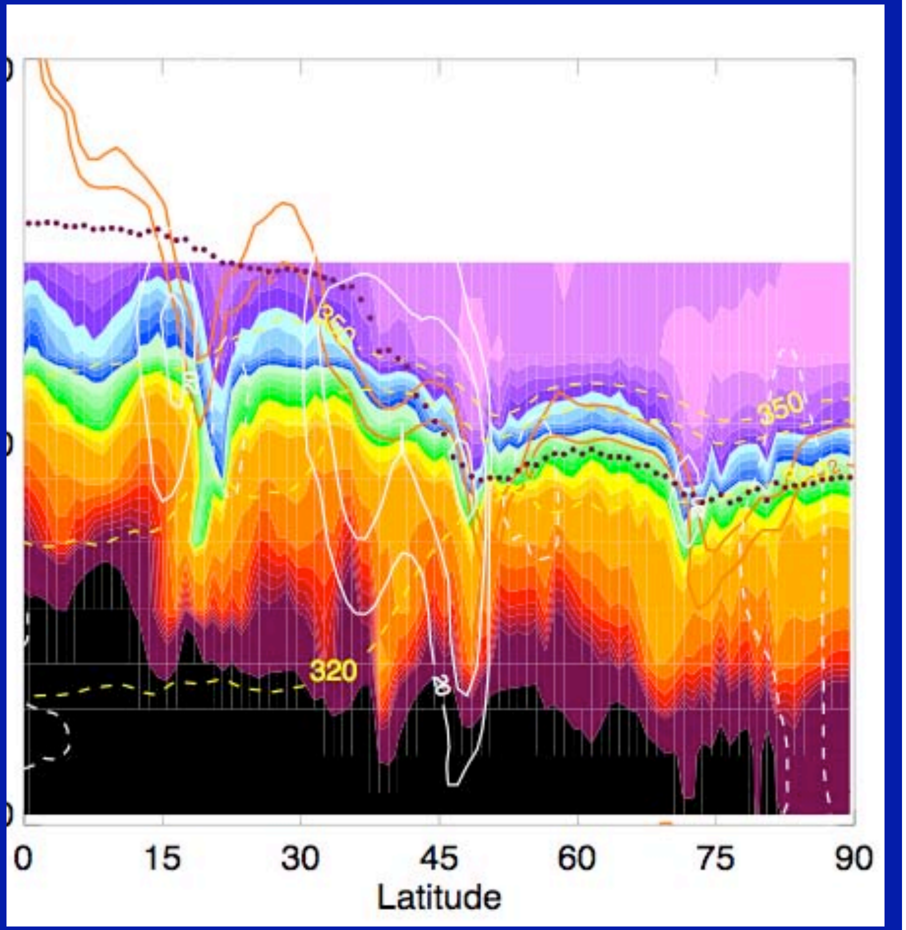
Pan et al., 2007

AIRS Ozone and Water Vapor

1x1 degree average, May 15, 2004, Lon=160 E

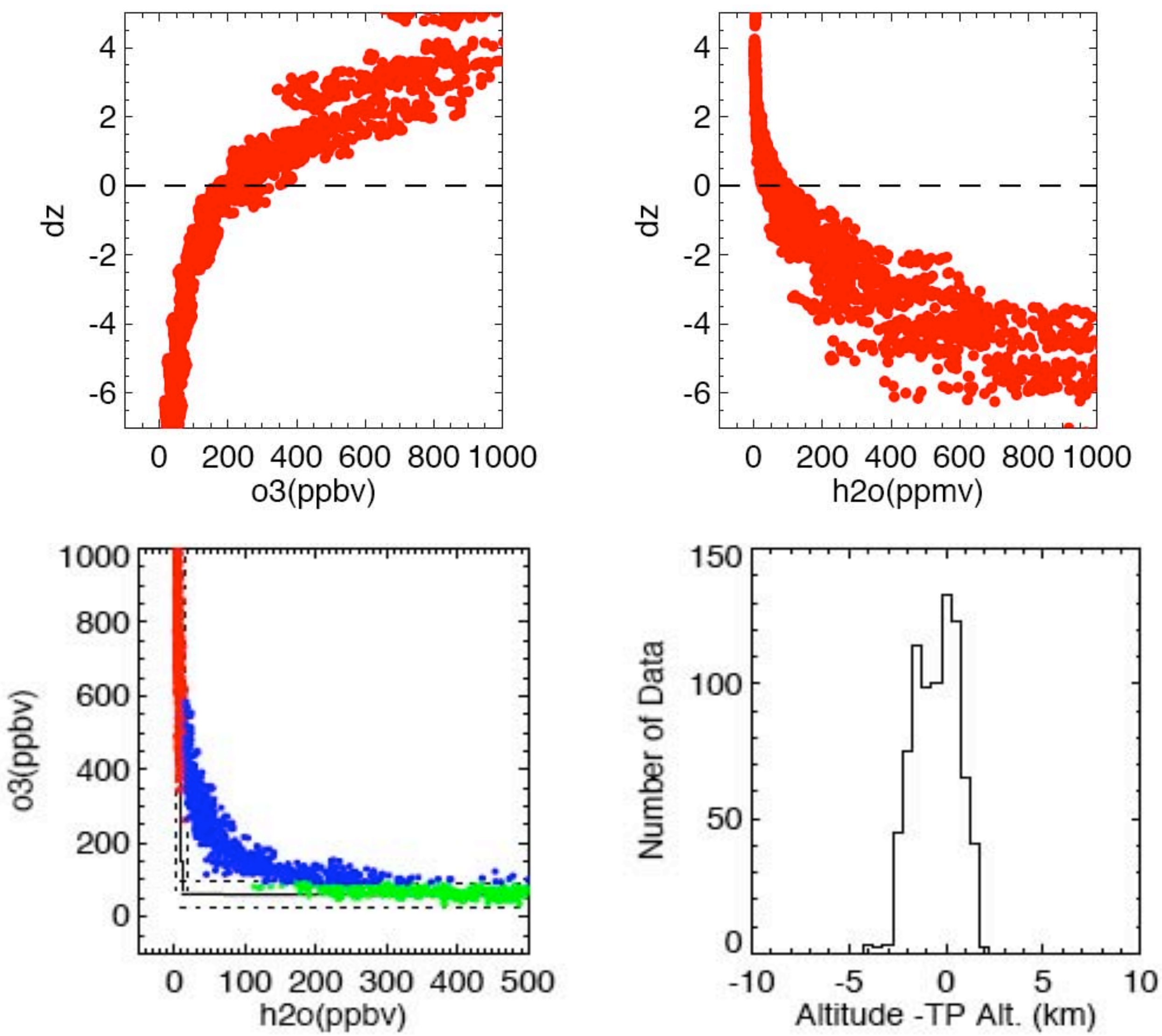


Ozone



Water Vapor

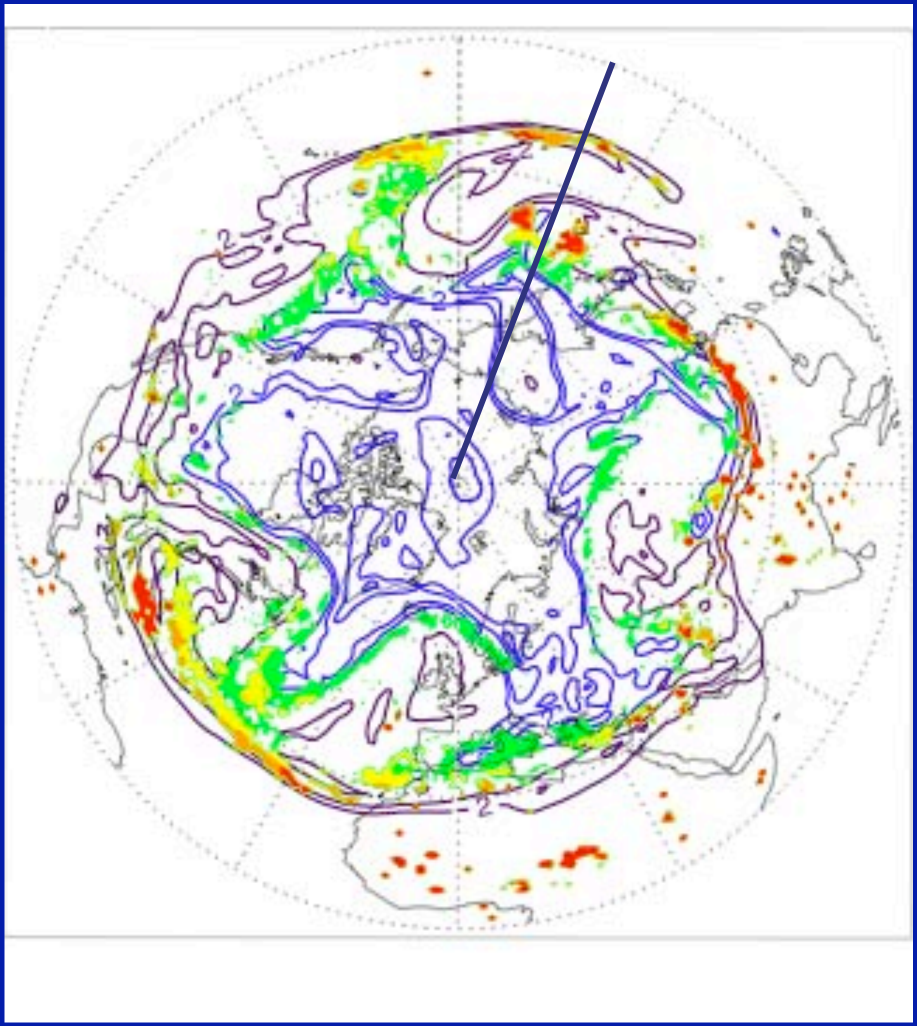
AIRS O_3–H_2O May 15, 2004, 65N



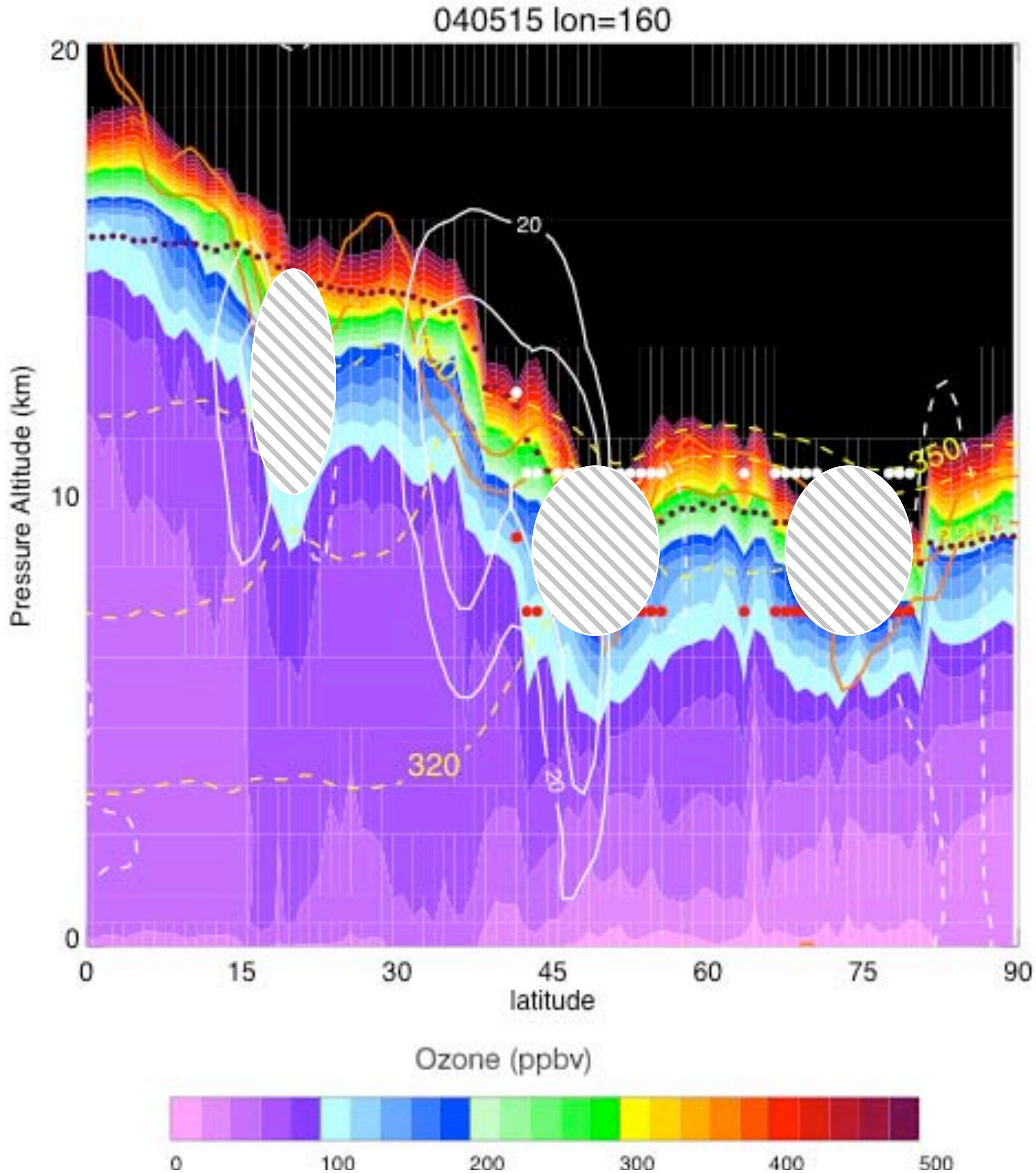
AIRS 20040515, "Deep Mixing"

diagnosis from O_3–H_2O

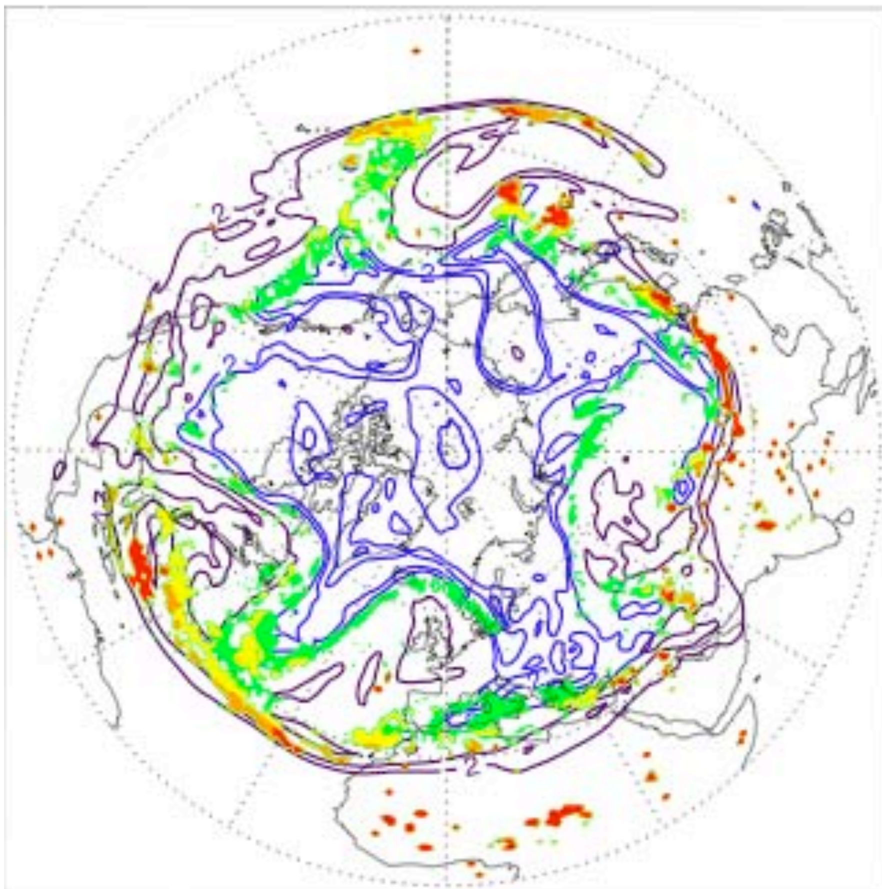
2,3,4,5 km below TP



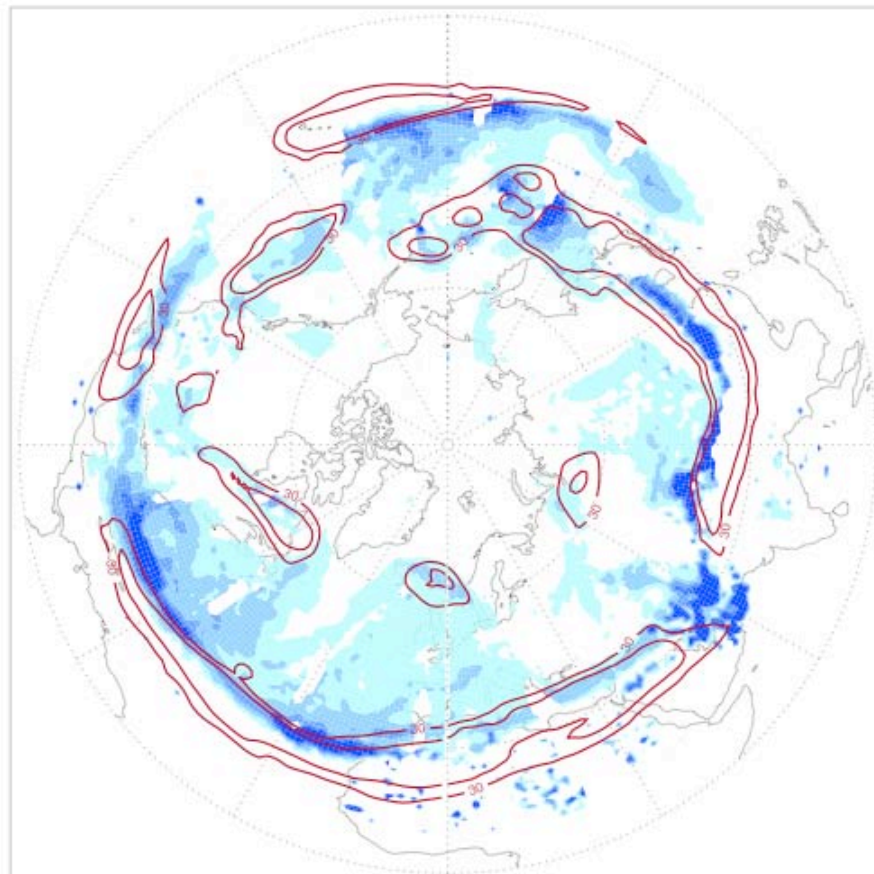
AIRS Ozone 040515



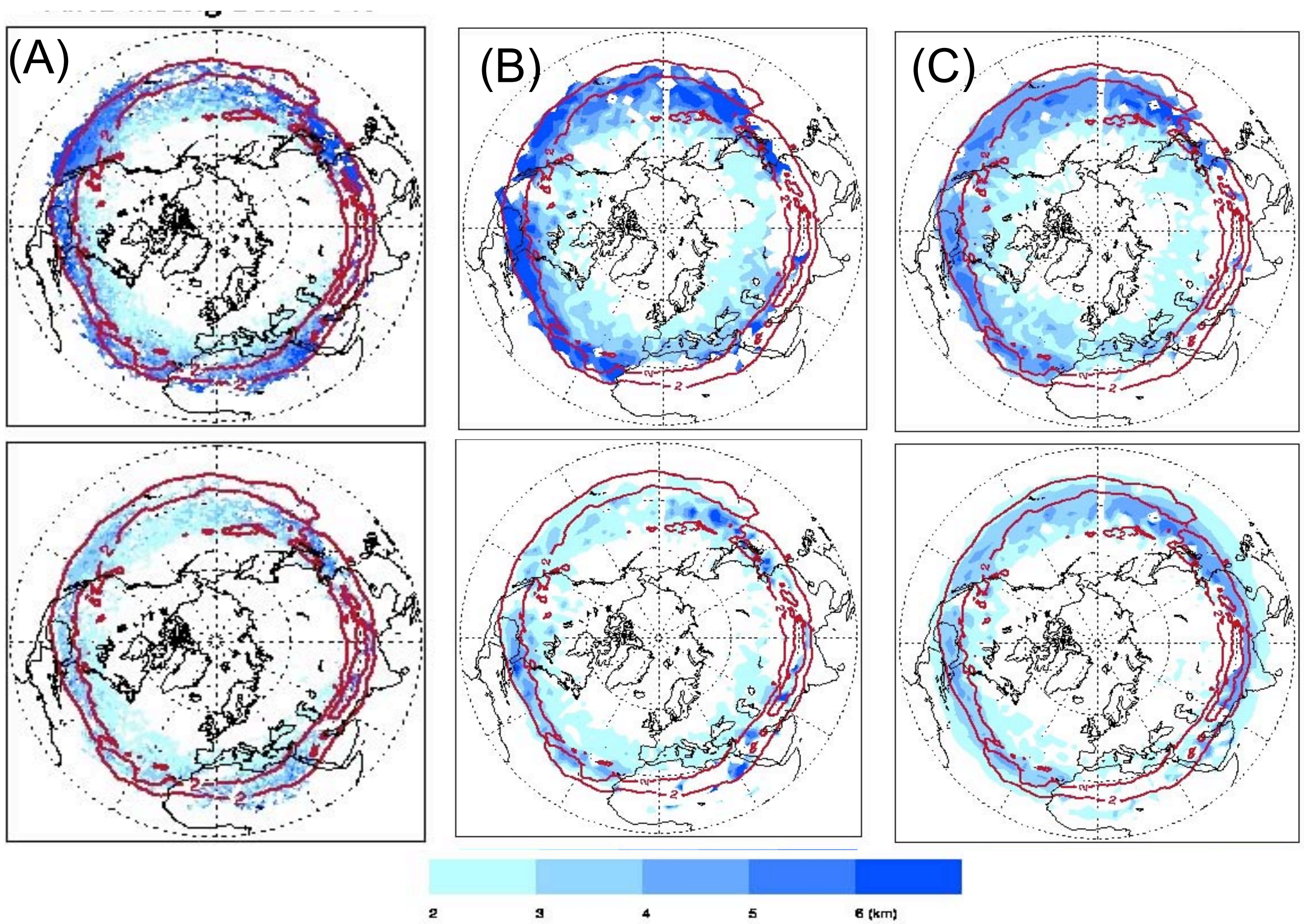
Mixing layer



depressed ozone pause



Does the region of preferred mixing coincide with the region of tropopause separation?



Mixed airmasses identified by tracer correlation using AIRS ozone and water vapor (upper panel), and ozonepause below thermal tropopause (lower panel). 3 different AIRS data plotted in (A) L3 (v4) 1x1 gridded data (B) L2 (v4) sub-sample (C) L2 (v5) sub-sample.

How consistent is the behavior of the ozone pause with dynamical tropopause statistically?

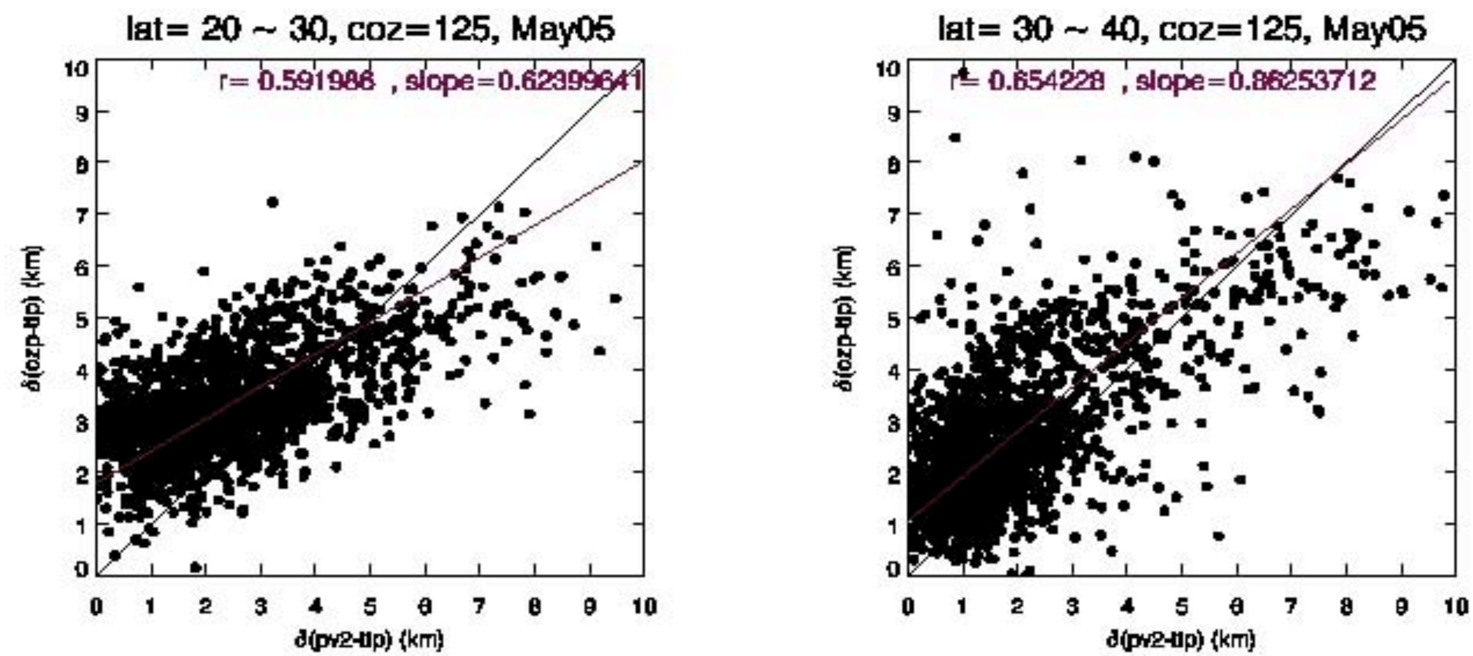


Figure: Removing high cloud pixels (cloud top altitude > 6 km) from AIRS L2 (v5) subsample, a strong correlation (correlation coefficient, r) of the separation between the dynamical tropopause and thermal tropopause and the ozonepause and thermal tropopause.

Stratosphere-Troposphere Analyses of Regional Transport Experiment (START08)

Science Objective: **Investigate transport processes that impact the chemical-microphysical distribution of the Ex-UTLS**

Co-Principal Investigators:

Elliot Atlas (Univ. of Miami), Kenneth P. Bowman (Texas A&M), Laura Pan (NCAR)

Co-Investigators:

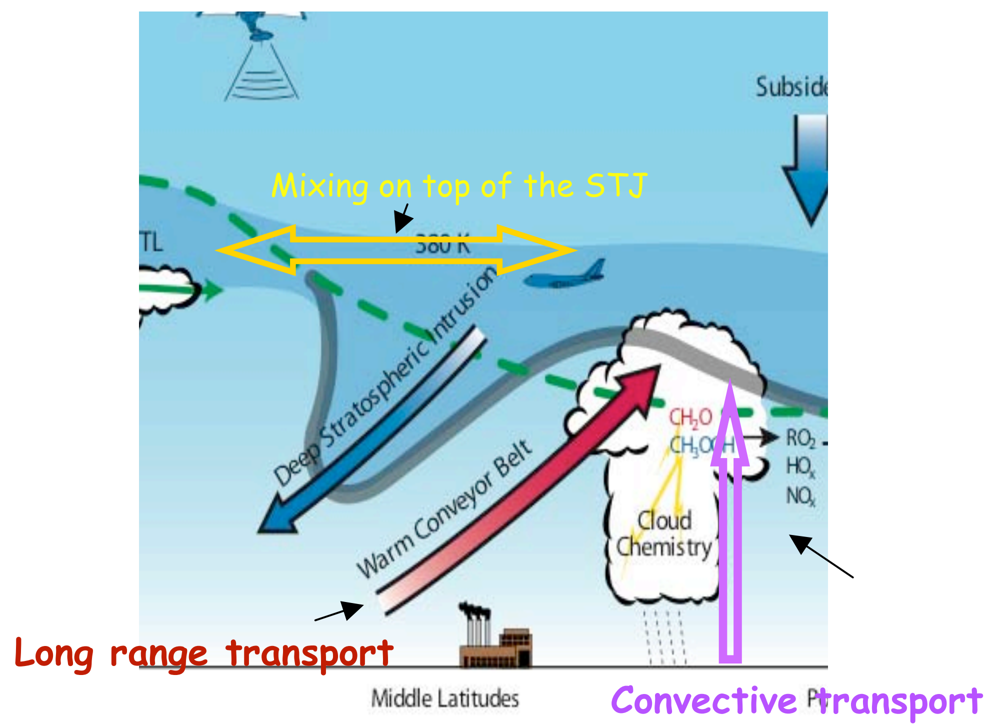
External:

Linnea Avallone (CU)
James Elkins (NOAA)
Fred Moore (CU)
Dale Hurst (CU)
Steve Wofsy (Harvard University)
Fuqing Zhang (Texas A&M)

NCAR:

Teresa Campos
Andy Heymsfield
Andy Weinheimer
Frank Flocke
Bill Randel
Sue Schauffler
Brian Ridley
Britt Stephens
Simone Tilmes

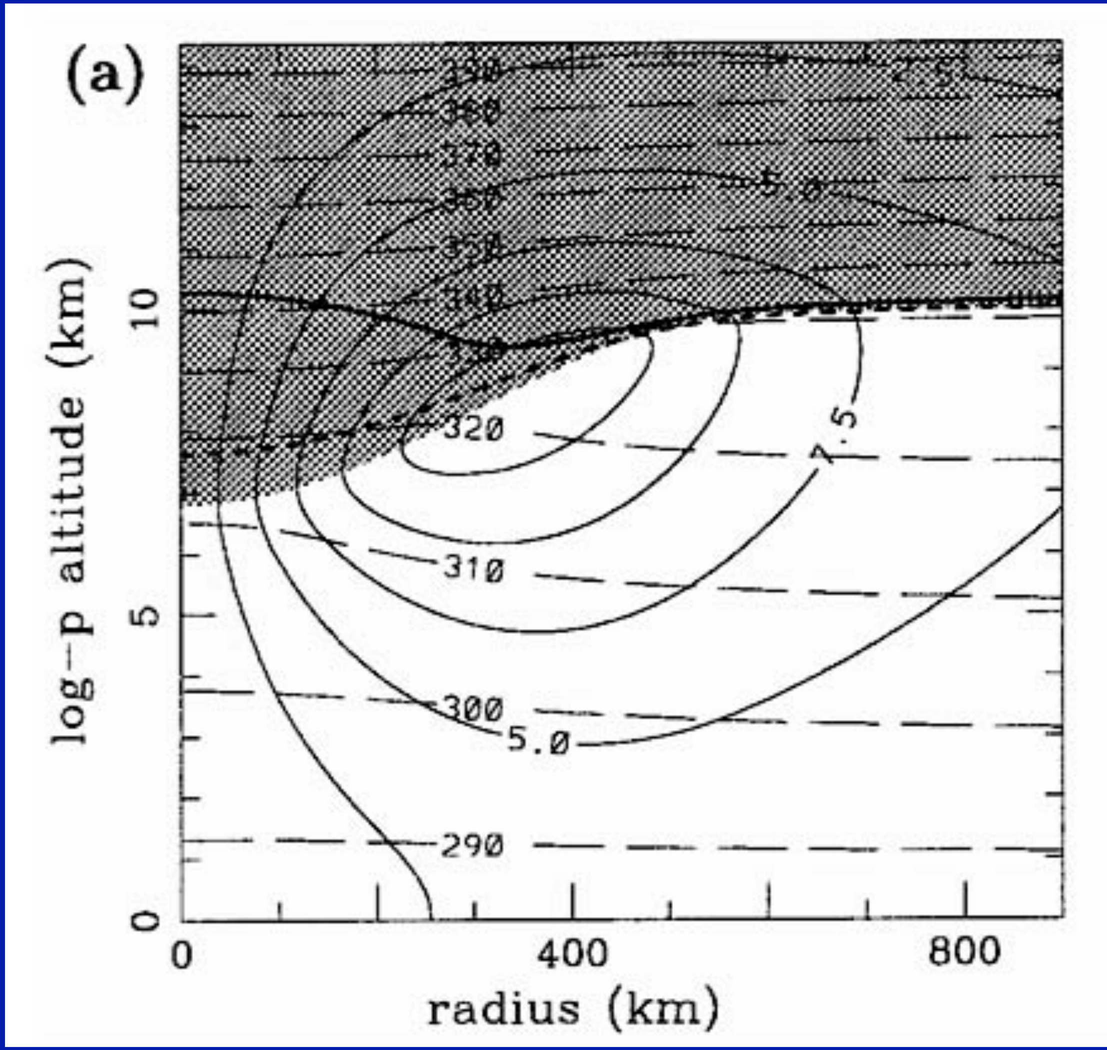
- April-June, 2008
- Flight operation from Jeffco
- Joint with HIPPO (global carbon)



Shadows of Monument Valley - Flight 051209


N677F
National Center for Atmospheric
New NSF/NCAR GV
Daybreak before take off 2005-12-21

Idealized model study: the dynamical tropopause is lower under cyclonic conditions



Wirth, 2001, 2003